Round 2

Welcome to the California Statewide Codes and Standards Enhancement (CASE) Team's Stakeholder Meeting on

High Performance Envelope

We will begin shortly.

In the meantime, please fill out the polls below.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Pacific Gas and Electric Company

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

SDGE
A Sempra Energy utility

LA DWP Los Angeles Department of Water & Power

SMUD

Welcome: Connect Your Audio

Audio – there are **three** options for connecting to the meeting audio: **Options 1 & 2** *recommended for those who wish to provide oral comments.*

To view options, click on the icon on the top ribbon, then select *Connect My Audio.*

1. **Dial-out:** receive a call from the meeting. *Please note this feature* ***requires a direct line.***
2. **Dial-in:** dial-in to the conference via phone. Conference phone number and room number code provided. *Please then* ***identify your line*** *by entering your unique user ID on your phone.*
3. Use the **microphone** from your computer/device.

Above*: audio conference settings pop-up box*

2022 TITLE 24 CODE CYCLE, PART 6

Second Utility-Sponsored Stakeholder Meeting

High Performance Envelope

Statewide CASE Team

April 23, 2020

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Meeting Guidelines – Computer/Device Users

Part 1a of 4 – Muting & Unmuting

Muting Guidelines:

To keep meetings running smoothly, all participants will be **muted upon entry**.

Participants will be **manually unmuted** by the Meeting Hosts.

Unmuting Guidelines:

If you are using your computer's microphone, in order to speak when prompted, you must first connect your audio by hovering over the icon, then clicking *Connect My Audio > Using Microphone (Computer/Device).*

Meeting Guidelines – Dial-out/Dial-in Phone Users

Part 1b of 4 – Muting & Unmuting

Muting Guidelines:

To keep meetings running smoothly, all participants will be **muted upon entry**.

Participants will be **manually unmuted** by the Meeting Hosts.

Unmuting Guidelines:

1. If you are dialed in to the meeting, Meeting Hosts will unmute your specific line when it is your turn to speak. Your line is then active.
2. If you have **locally** muted your device, please also make sure to unmute before speaking.

Meeting Guidelines – Dial-in Phone Users

Part 2 of 4 - Pairing

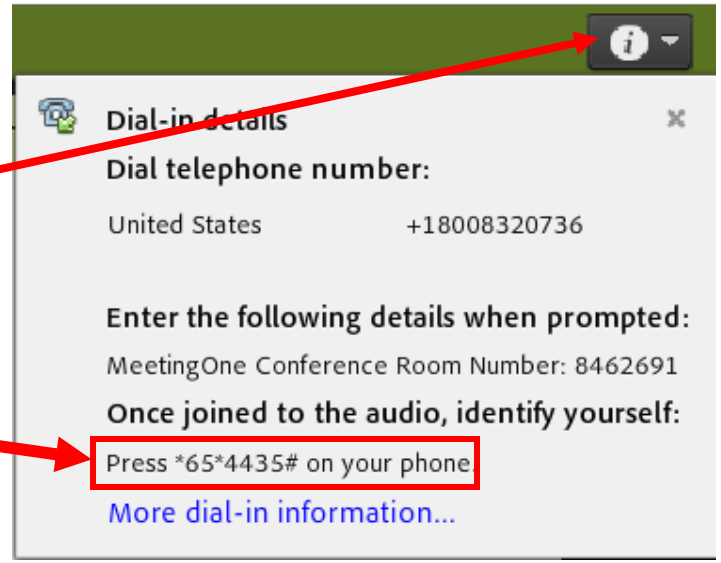
Pairing Guidelines:

If you **dialed in by phone** to join meeting audio, please **pair your line**. Dial-out users will be paired automatically.

- Navigate to the (i) button in the top right of your screen.
- Click the pull-down menu and ***identify your line*** *by entering your unique user ID on your phone.*

Steps to Pair Line:

1. **Select (i) button** pull-down on the top right of Adobe Connect window;
2. **Identify** your line using your unique code.

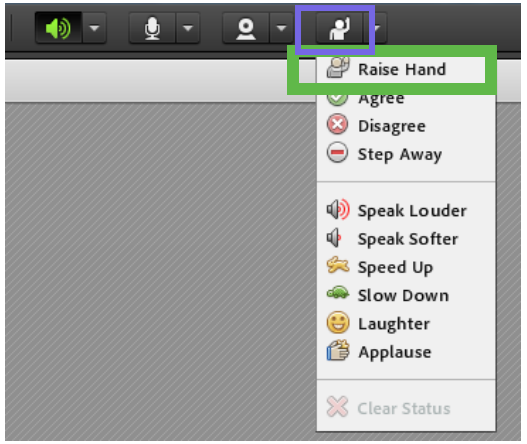


Meeting Guidelines – All Users

Part 3 of 4 - Participation

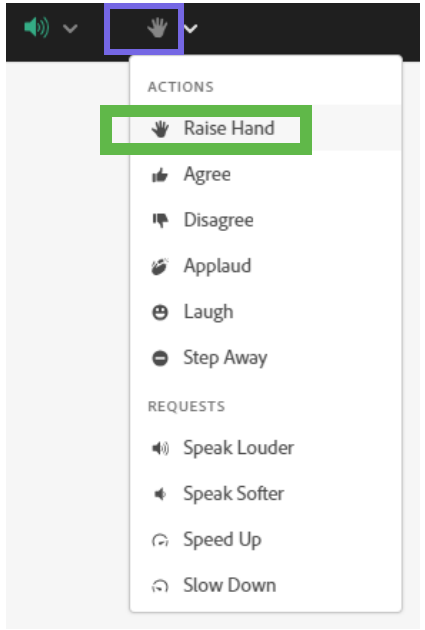
Participation Guidelines:

- **Questions & Comments**
  - Click ***"Raise Hand"*** if you would like to speak. Those with a hand raised will be called on by the speaker.
    - Meeting Hosts will then unmute your line, enabling others to hear your audio.
  - All questions and comments are also welcome via the chat window.
- **Other Meeting Feedback**
  - Provide live meeting feedback from the **top toolbar drop-down**.



***Above**: feedback view for Adobe Connect app users.*

***Below**: feedback view for HTML users.*



Meeting Guidelines – All Users

Part 4 of 4 – Discussion Ground Rules

- **We want to hear your thoughts.**
  - Supporting and opposing viewpoints are welcome.
- **When making comments, please:**
  1. Raise your hand; you will be unmuted and called on;
     - Computer/device users have the *additional* step to *Connect My Audio*
  2. Clearly state your name and affiliation prior to speaking
- Meeting Hosts will **place you back on mute** when done speaking.
- **Calls are recorded** for note development, recordings will not be publicized.
- Notes and presentation material will be posted on Title24Stakeholders.com/events.

Agenda

1	**Meeting Guidelines**	*8:30 am*
2	**Opening Remarks** from the California Energy Commission	*8:35 am*
3	**Overview & Welcome** from the Statewide Utility Team	*8:40 am*
4	**Presentation I:** High Performance Envelope	*8:45 am*
5	Wrap Up & Closing	*11:15 am*

Opening Remarks:
California Energy Commission

Policy Drivers: Building Standards

The following policy documents establish the goal for new building standards:

- **2008 CPUC/CEC Energy Action Plan** – ZNE for residential buildings by 2020 and nonresidential buildings by 2030
- **SB 100** – Clean electricity by 2045
- **B-55-18** – Governor Jerry Brown's Executive Order to achieve carbon neutrality
- **AB 3232** – Assess the potential for the state to reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40 percent below 1990 levels by January 1, 2030

2022 Updated Standards Schedule

Estimated Date	ACTIVITY OR MILESTONE
November 2018 – November 2019	Updated Weather Data Files
November 2018 – December 2019	Metric Development
November 2018 - July 2019	Measures Identified and Approved
April 24, 2019	Present the Efficiency Measure Proposal Template for public to submit measures
October 17, 2019	Compliance Metrics and Climate Data Workshop
August 2019 – November 2019	First Round of Utility-Sponsored Stakeholder Workshops
January 2020	Research Version of CBECC Available with new weather data files and updated metric
March 2020 – April 2020	Second Round of Utility-Sponsored Stakeholder Workshops
March 10, 2020	Staff Workshop on the proposed changes for the ATTCP program
March 26, 2020	Staff Workshop on the EDR1
March 2020 – May 2020	All Initial CASE/PUBLIC Reports Submitted to Commission
July 2020 – August 2020	All Final CASE/PUBLIC Reports Submitted to the Commission
August 2020 – October 2020	Commission-Sponsored Staff Workshops
September 2020 – November 2020	Express Terms Developed (including New Multifamily Section)
February 2021	45-Day Language posted and sent to list serve, Start of 45-Day review/comment period
March 2021	Lead Commissioner Hearing
July 2021	Adoption of 2022 Standards at Business Meeting
September 2021	Final Statement of Reasons Drafted and Approved
July 2021	Adoption of CALGreen (energy provisions) - Business Meeting
December 2021	Approval of the Manuals
October 2021	Final Rulemaking Package delivered to CBSC
December 2021	CBSC Approval Hearing
January 2021	Software, Compliance Manuals, Electronic Documents Available to Industry
January 1, 2023	Effective Date

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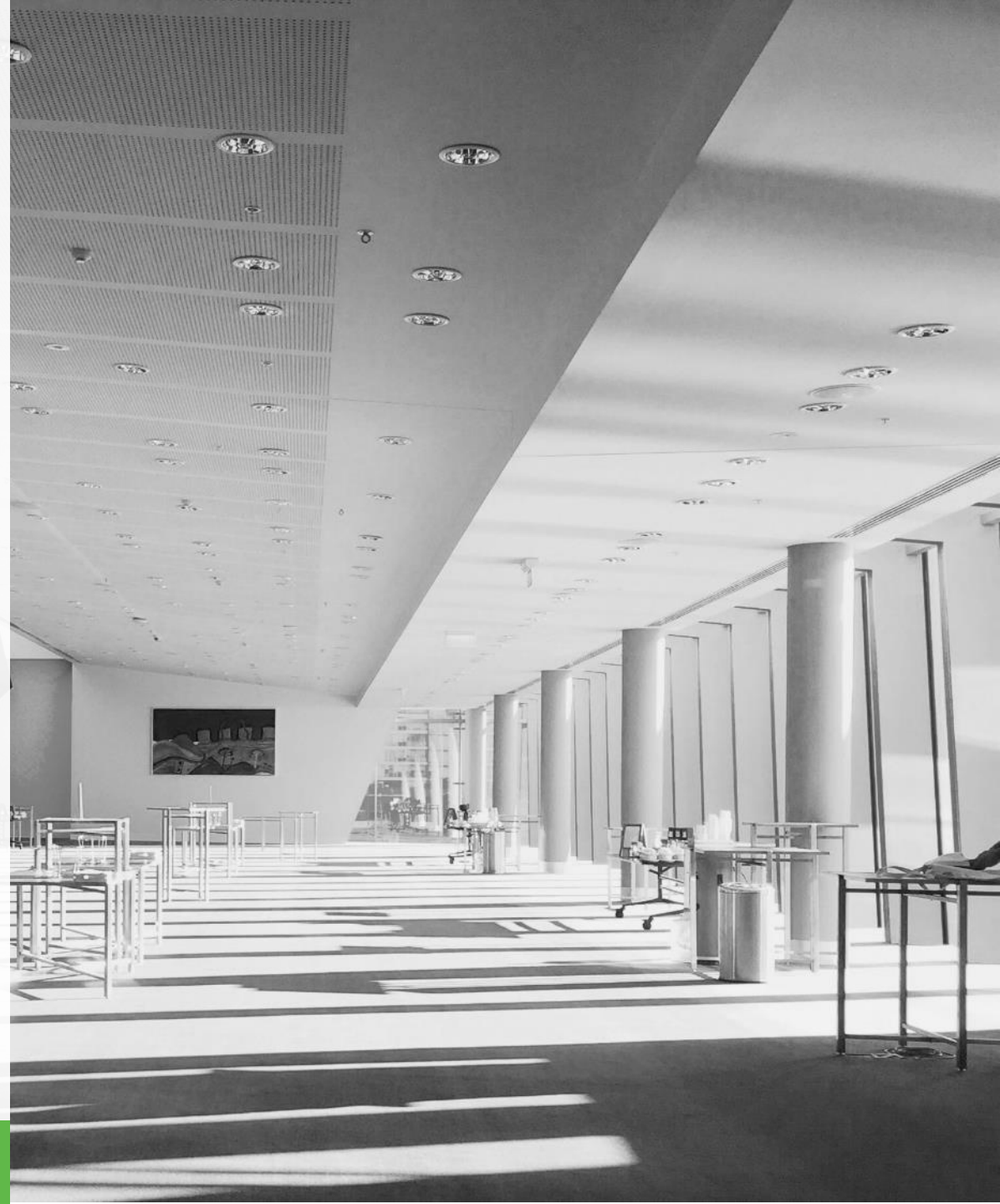
More information on pre-rulemaking for the 2022 Energy Code at:
https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Title 24, Part 6 Overview

Kelly Cunningham
Codes and Standards
Pacific Gas & Electric



Statewide Utility Codes and Standards Team

Actively support the California Energy Commission in developing proposed changes to the Energy Code (Title 24, Part 6) to achieve significant statewide energy use reductions through the development of code change proposals for the 2022 cycle that are:

Feasible | Cost effective | Enforceable | Non-proprietary

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SDGE — A Sempra Energy utility

LA DWP Los Angeles Department of Water & Power

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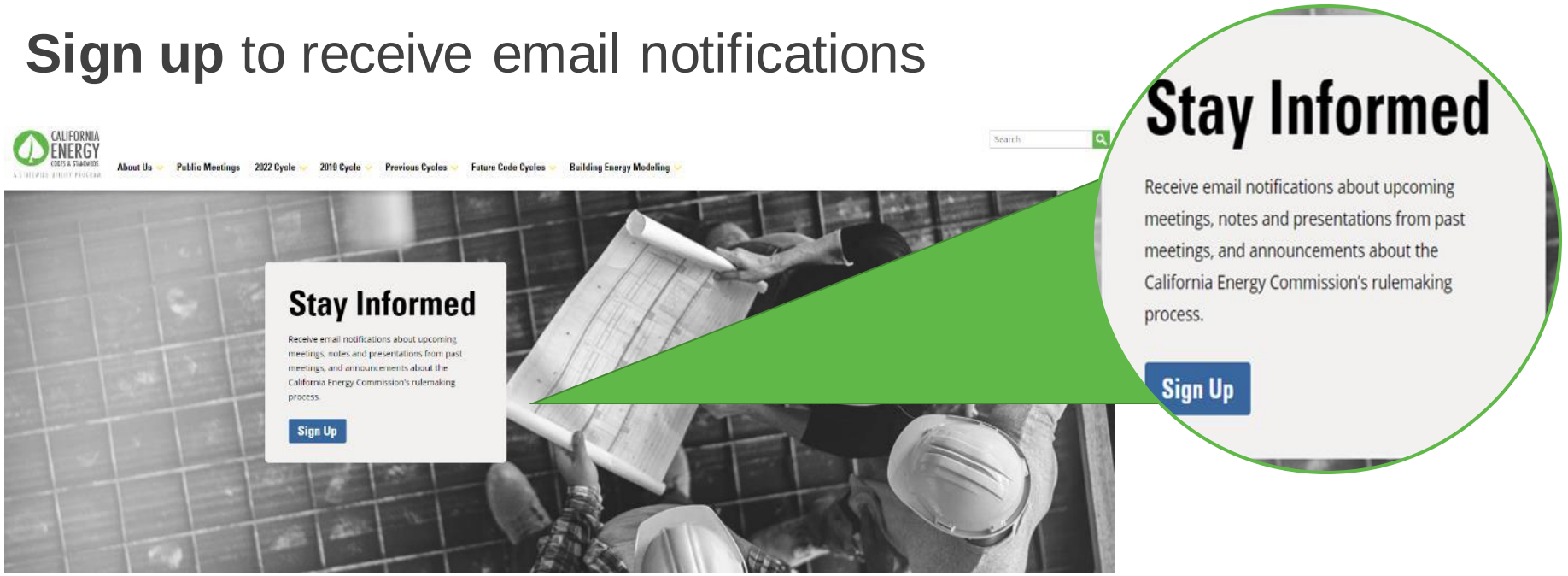
Utility-Sponsored Stakeholder Meetings

- All meetings can be attended **remotely**
- Check Title24Stakeholders.com/events for information about meetings and topic updates
- **Sign up** to receive email notifications

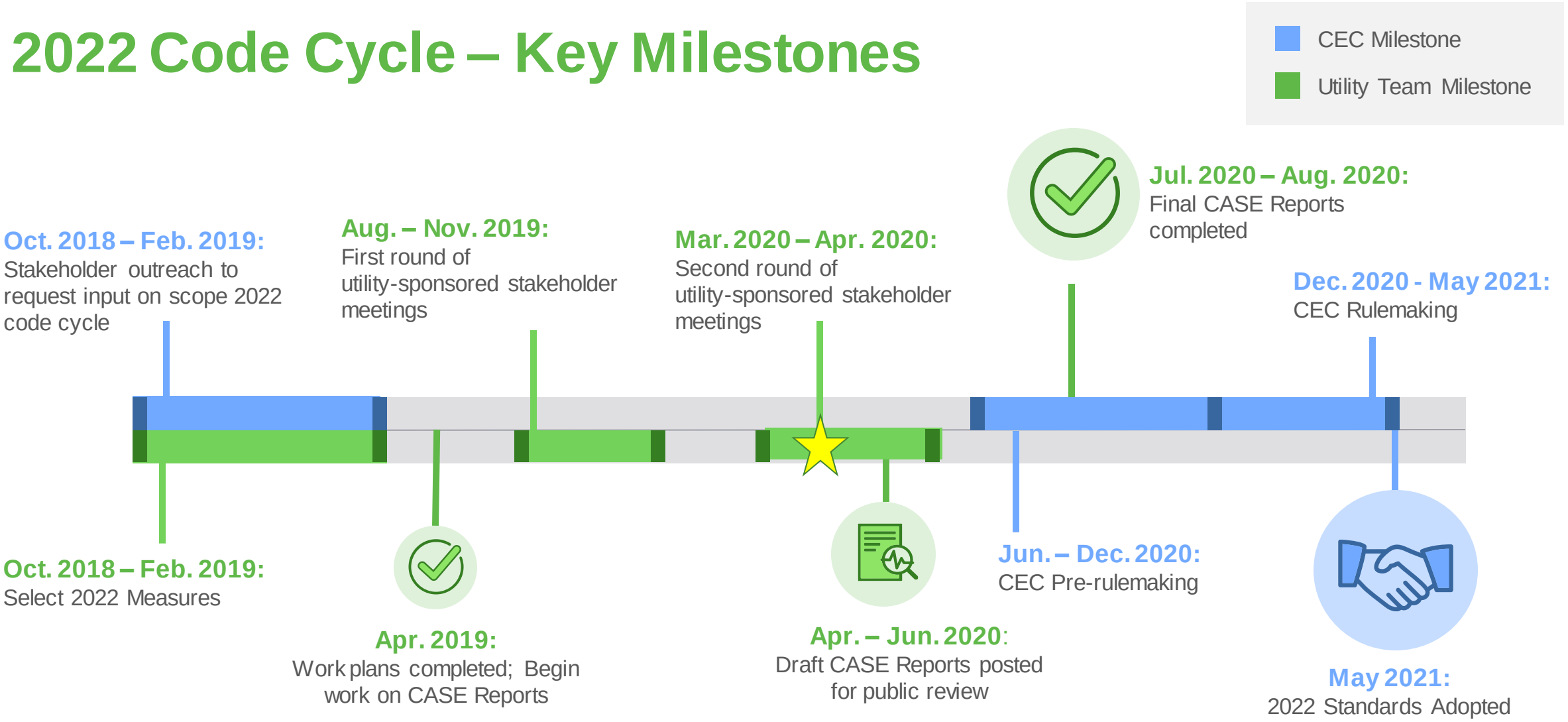


Second Round Utility-Sponsored Stakeholder Meetings

Meeting Topic	Building Type	Date
Lighting	NR/MF	Tuesday, March 3, 2020
Single Family Whole Building	SF	Thursday, March 5, 2020
Nonresidential and Single Family HVAC Part 1: Data Centers, Boilers, Air Distribution, Variable Capacity	NR/SF	Thursday, March 12, 2020
Water Heating and Multifamily All Electric Package	MF	Tuesday, March 17, 2020
Single Family Grid Integration	SF	Thursday, March 19, 2020
Multifamily HVAC and Envelope	MF	Wednesday, March 25, 2020
Covered Processes Part 1: Refrigeration System Opportunities	NR	Thursday, April 2, 2020
Nonresidential HVAC and Envelope Part 2: Reduced Infiltration, HVAC Controls (Air Efficiency, DOAS)	NR	Tuesday, April 14, 2020
Covered Processes Part 2: Controlled Environment Horticulture	NR	Thursday, April 16, 2020
Nonresidential Envelope: High Performance Envelope	NR	Thursday, April 23, 2020
Multifamily Restructuring	MF	Thursday, May 7, 2020

Sign up for all meetings at title24stakeholders.com/events/

2022 Code Cycle – Key Milestones



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Tools ♠ Training ♠ Resources

to help you decode Title 24, Part 6 and Title 20

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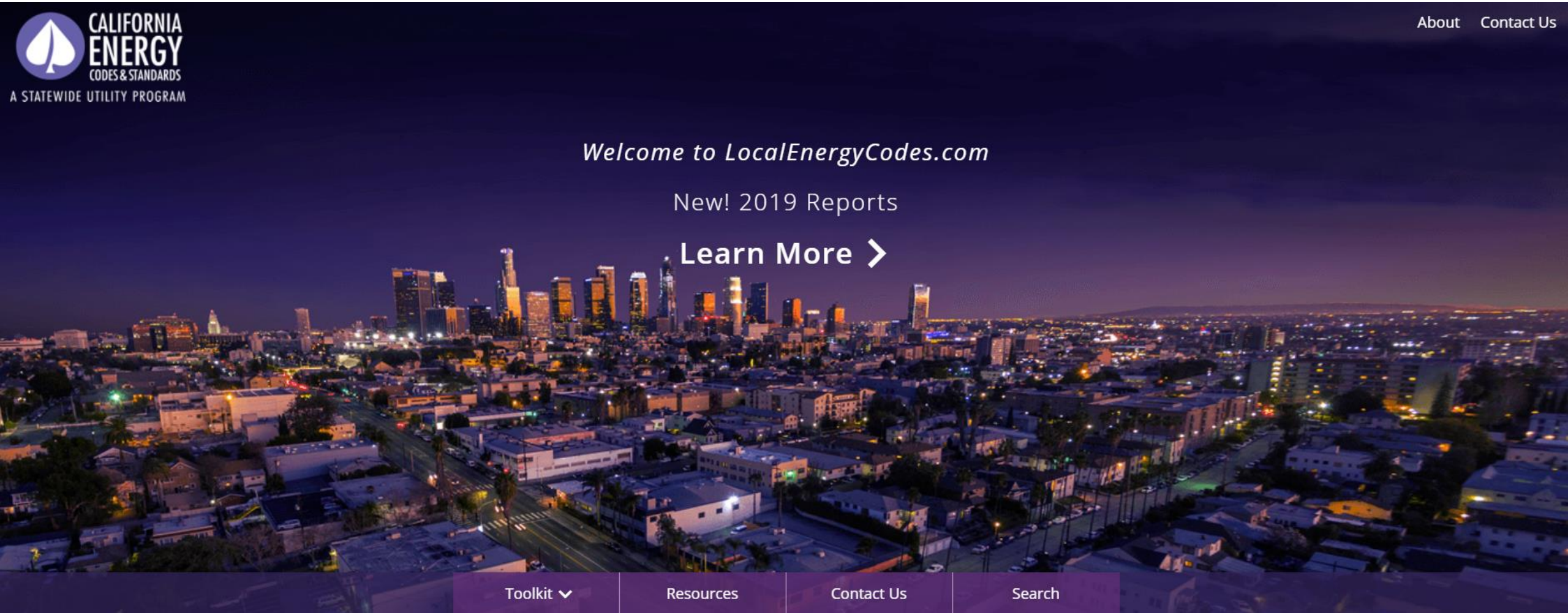
This program is funded by California utility customers and administered by Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E®), Southern California Edison Company (SCE), and Southern California Gas Company (SoCalGas®) under the auspices of the California Public Utilities Commission.



The **Codes and Standards Reach Codes Program** provides technical support to local jurisdictions considering adopting a local energy and efficiency ordinance

www.LocalEnergyCodes.com

This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
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Meeting Guidelines

Pairing

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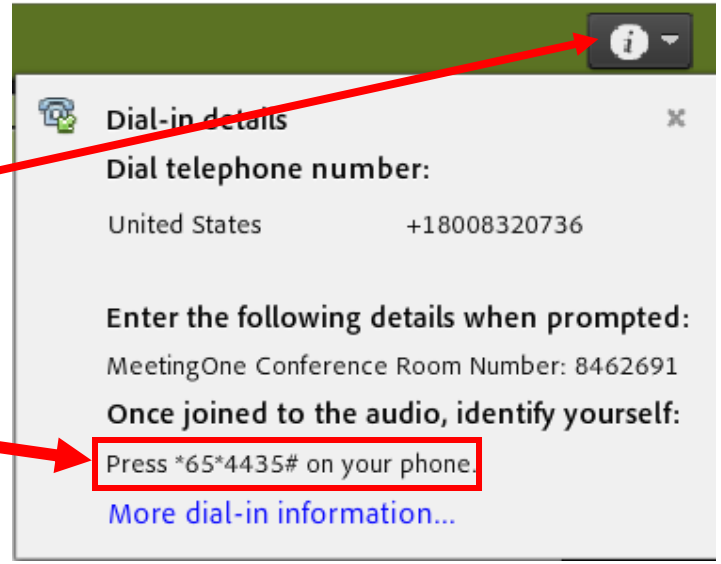


2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

High Performance Envelope

Codes and Standards Enhancement (CASE) Proposal
Nonresidential | High Performance Envelope

Kiri Coakley, Benny Zank, Simon Silverberg and Alamelu Brooks, *Energy Solutions*
Eric Shadd, *Determinant*
April 23, 2020

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Agenda

1. Today's Objectives
2. Background
3. Submeasure Presentations:
   - 3.1 *High Performance Windows*
     - *RSHGC Calculation*
     - *U-factor and SHGC Updates*
   - 3.2 *Opaque Envelope*
   - 3.3 *Roof Alterations*
   - 3.4 *Cool Roofs*
4. Questions and Next Steps

Today's Objectives

All submeasures will focus on:

1. **Reviewing** energy and cost calculations
2. **Analyzing** proposed code language
3. **Discussing** updates since first stakeholder meeting

High Performance Envelope Background

Code Change Proposal Summary

Submeasure*	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated
High Performance Windows	Prescriptive	Yes	110.6	NRCC-ENV-01-E
			130.1	
			140.3	
Opaque Envelope	Prescriptive	Yes	140.0	NRCC-ENV-01-E
			140.3	
Roof Alterations	Prescriptive	Yes	100.1	NRCC-ENV-E
			141.0(b)2B	
Cool Roofs	Prescriptive	No	140.3(a)	NRCC-ENV-01-E
			141.0(b)2B	

*The thermal bridging submeasure, presented in the first utility-sponsored stakeholder meeting, is no longer being pursued this code cycle.

Code Change Proposal: Additional Resources

First-Utility Sponsored Meeting

The Statewide CASE Team held its first utility-sponsored stakeholder meeting for this topic on **October 24, 2019**

Resources on Title24stakeholders.com

Presentation slides and Submeasure summary documents available that cover the following:

- ✓ Measure Background
- ✓ Market Overview & Analysis
- ✓ Technical Feasibility
- ✓ Compliance & Enforcement
- ✓ Draft Code Language

Also available in the **resources tab in today's presentation.**

Submeasure A: High Performance Windows

Submeasure B: Opaque Envelope

Submeasure C: Roof Alterations

Submeasure D: Cool Roofs

Code Change Proposal Summary: High Performance Windows

Update	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated	Compliance Manuals Updated
U-factor, SHGC	Prescriptive	Yes	110.6	NRCC-ENV-01-E	Section 3-3
			130.1		
			140.3		
RSHGC Calculation	Prescriptive	Yes	100.1	None	
			130.1		
			140.3		

Description of Changes

- This proposal considers improvements to thermal performance factors for windows in nonresidential buildings
- RSHGC
  - Moved from the Daylighting Measure
  - Overhang exception will align with projection factor that is used for PAF and RSHGC

High Performance Windows

RSHGC Calculation Update

Energy and Cost Impacts

- Assumptions & Methodology
- Energy Impacts

Definition of Baseline and Proposed Conditions

Baseline Conditions

Proposed Conditions

	Baseline	Proposed Conditions
Window azimuth (orientation):	0, 45, 90, 135, 180, 225, 270, 315	Same as baseline
Minimally compliant with	2019 Code	Same as baseline
Shading	None	• Exterior horizontal slat (louver) shading • Cutoff: 15, 30, 45, 60, 75 • Tilt: 0, 10, 20, 30, 40 • Reflectance: 0, 30, 50, 70

Methodology for Energy Impacts Analysis: High Performance Windows

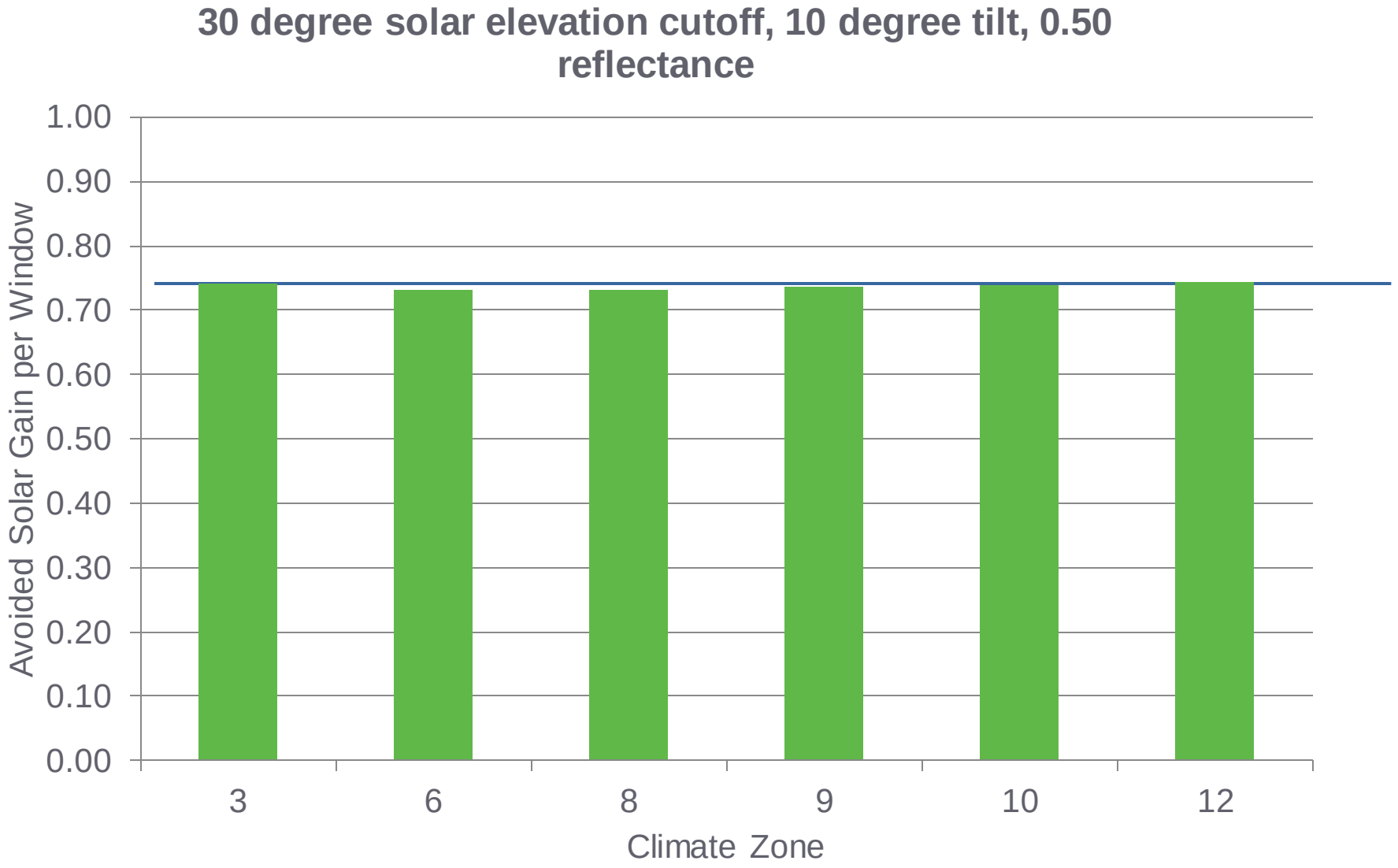
- Energy modeling was conducted in **EnergyPlus** to evaluate savings per square foot of floor within Energy Commission building prototypes. For the RSHGC equation savings are on a per window basis.

	RSHGC Update
Tools Used	CBECC-Com, OpenStudio, Ruby, EnergyPlus, Python, Excel
Building Prototypes Used	Small Office (Not affected by internal loads or window size)
Climate Zones Modeled	3, 6, 8, 9, 10, 12

Assumptions for Energy Impacts Analysis

- **Baseline:** no window shading, **Proposed:** window shading
- **30 year** TDV
- Selected climate zones are sufficient for statewide weighted average (~70% FC)
- Exterior horizontal slat with zero tilt and zero reflectance to model overhang shading

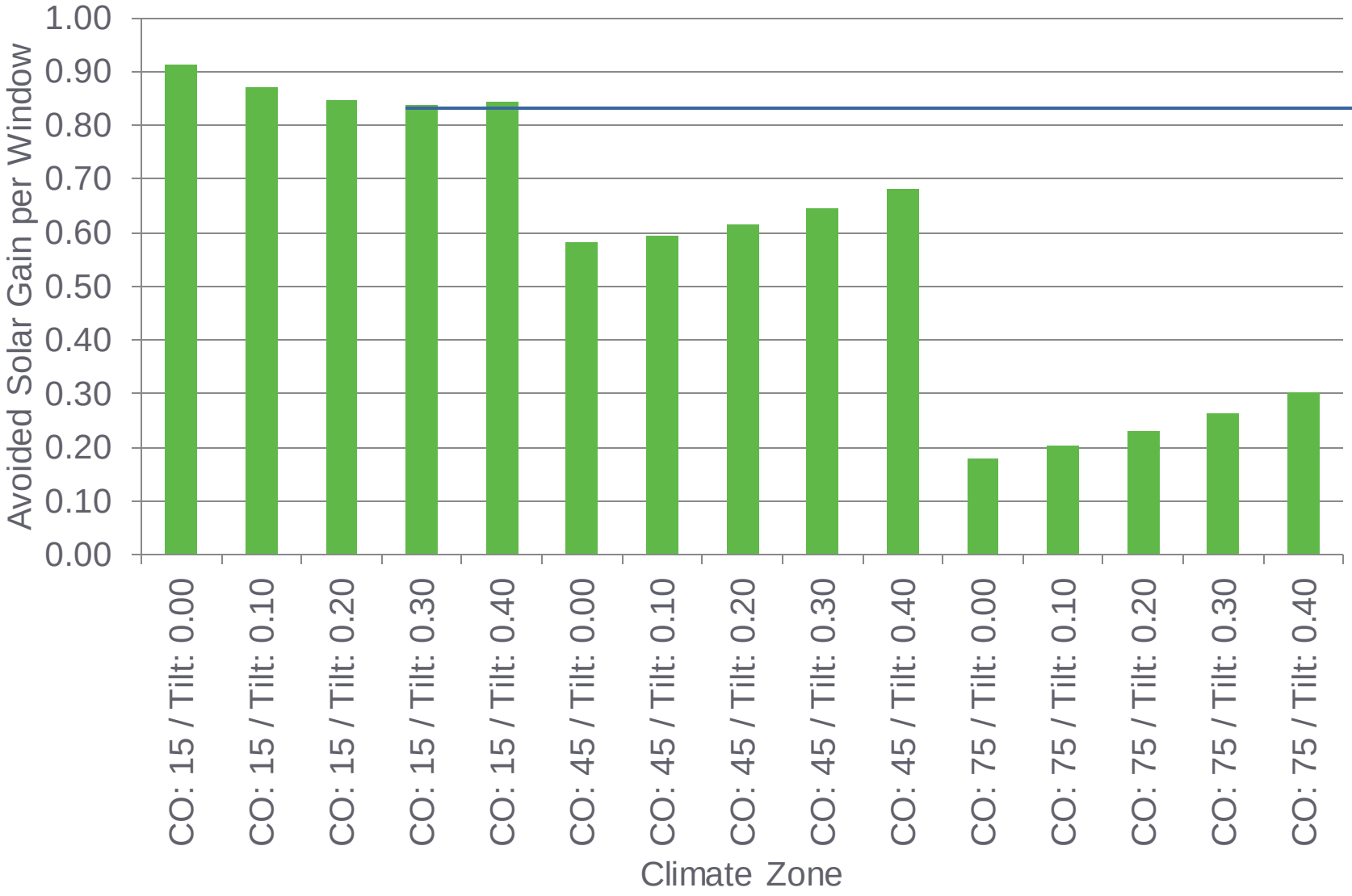
Solar Gain Savings: Southeast window



~0.74

Variation – Not much variation with climate zone.

Solar Gain Savings: Geometries, Climate Zone 12



0.84

Relative minimum – for low cutoff angles

- Low tilt = interreflection
- High tilt = reflecting to exterior
- Least savings is somewhere in between.

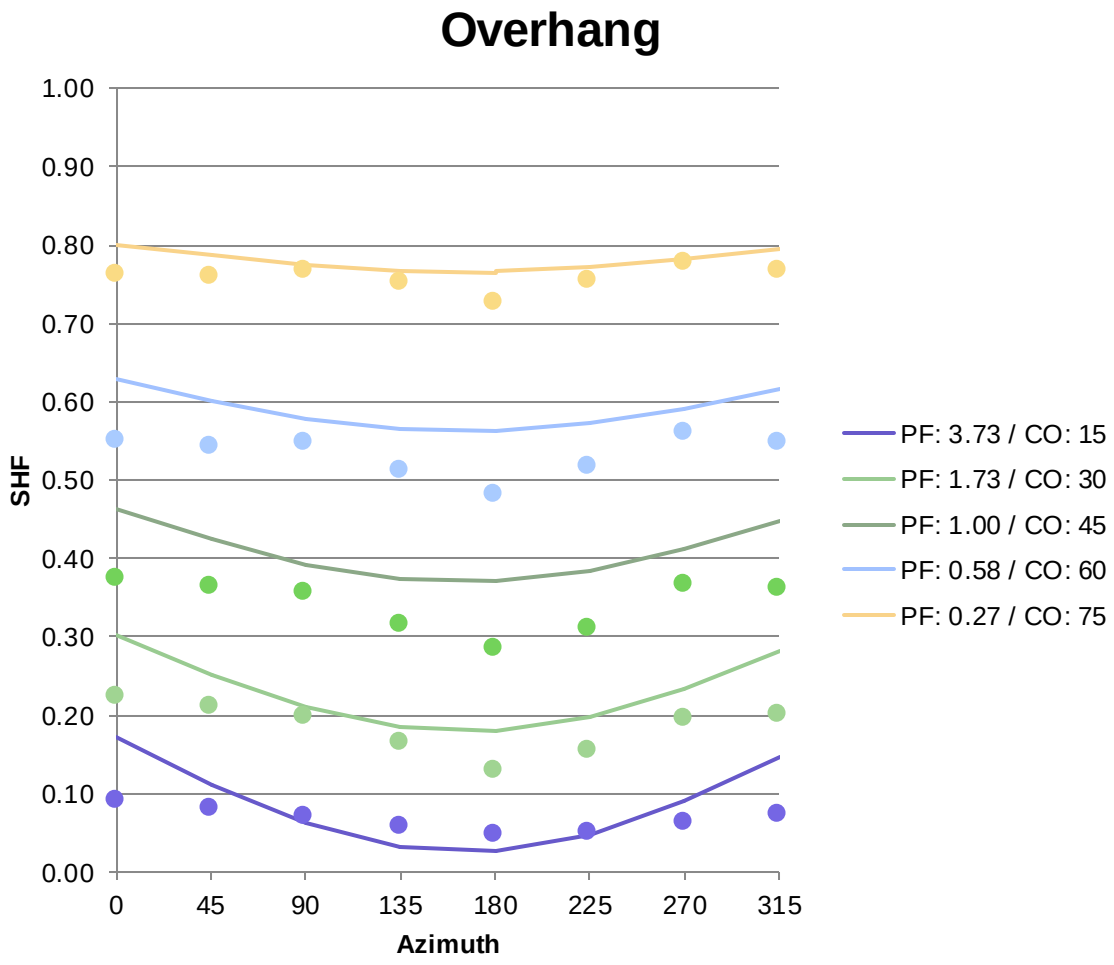
Statewide RSHGC Equation

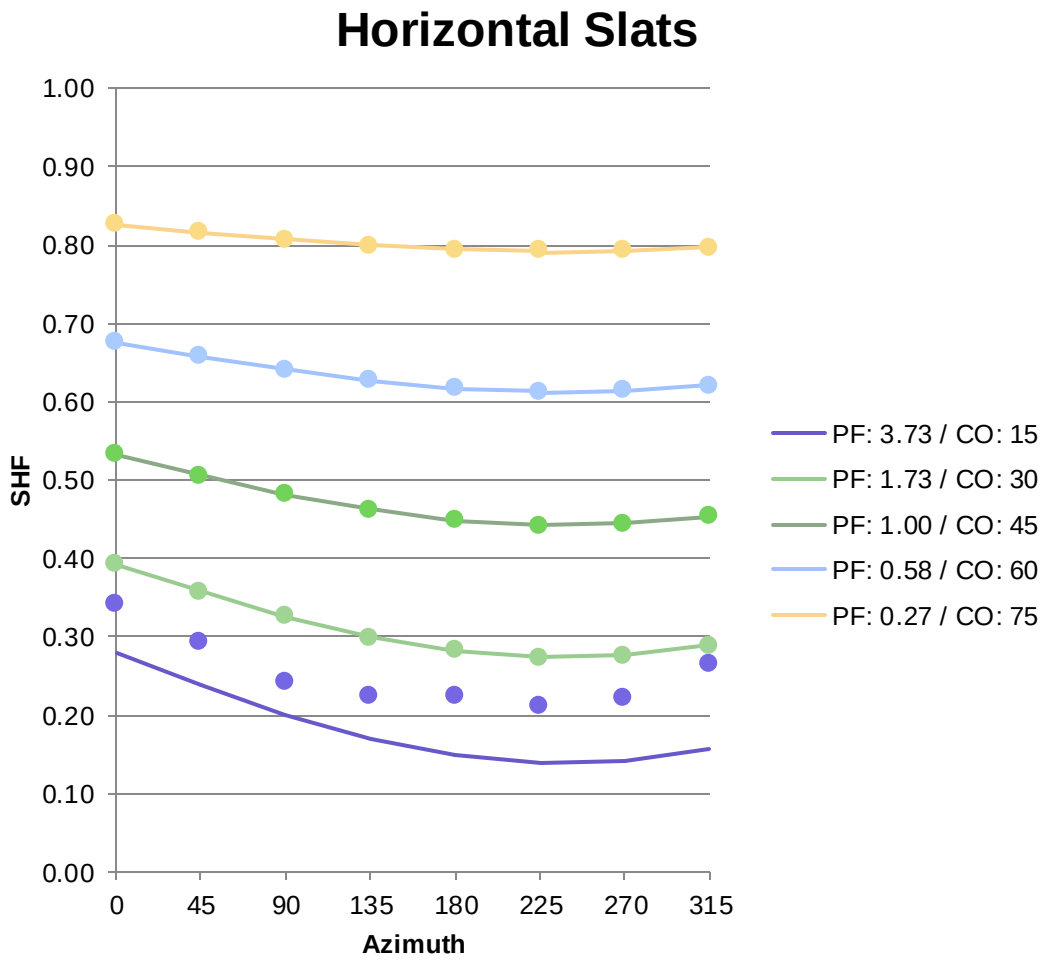
$$RSHGC = SHGC_{win}[1 + a \times (e^{-PF} - 1)(\sin(b \times Az) - c)]$$

	a	b	c
Overhang	0.150	0.130	5.67
Horizontal Slat	0.144	0.133	5.13

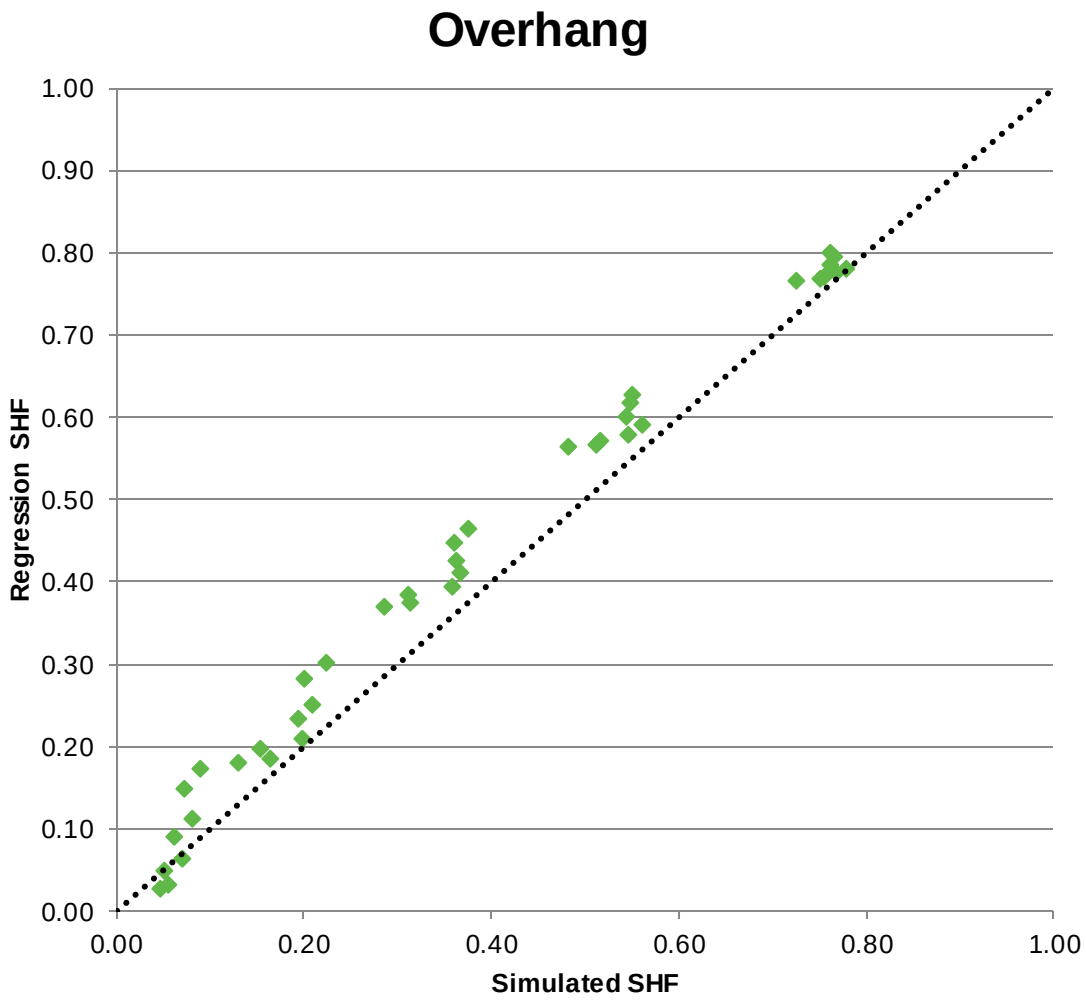
- Curve fit to similar variables as current equation (PF = H/V).
- Climate zone weighted so can be statewide
- Lowest saving reflection, tilt = No verification required
- Overhang assumed to be same as zero reflectance, zero tilt exterior horizontal slat

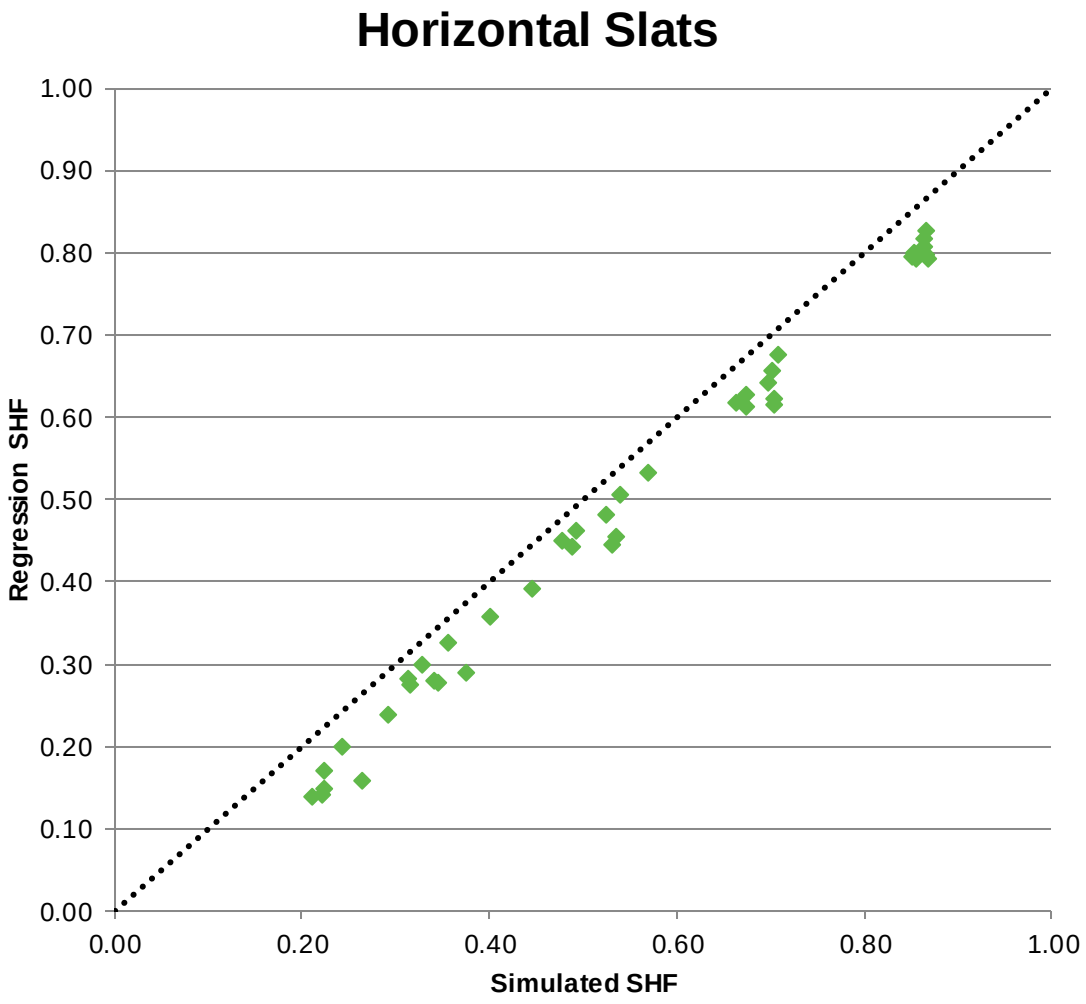
Statewide RSHGC Equation





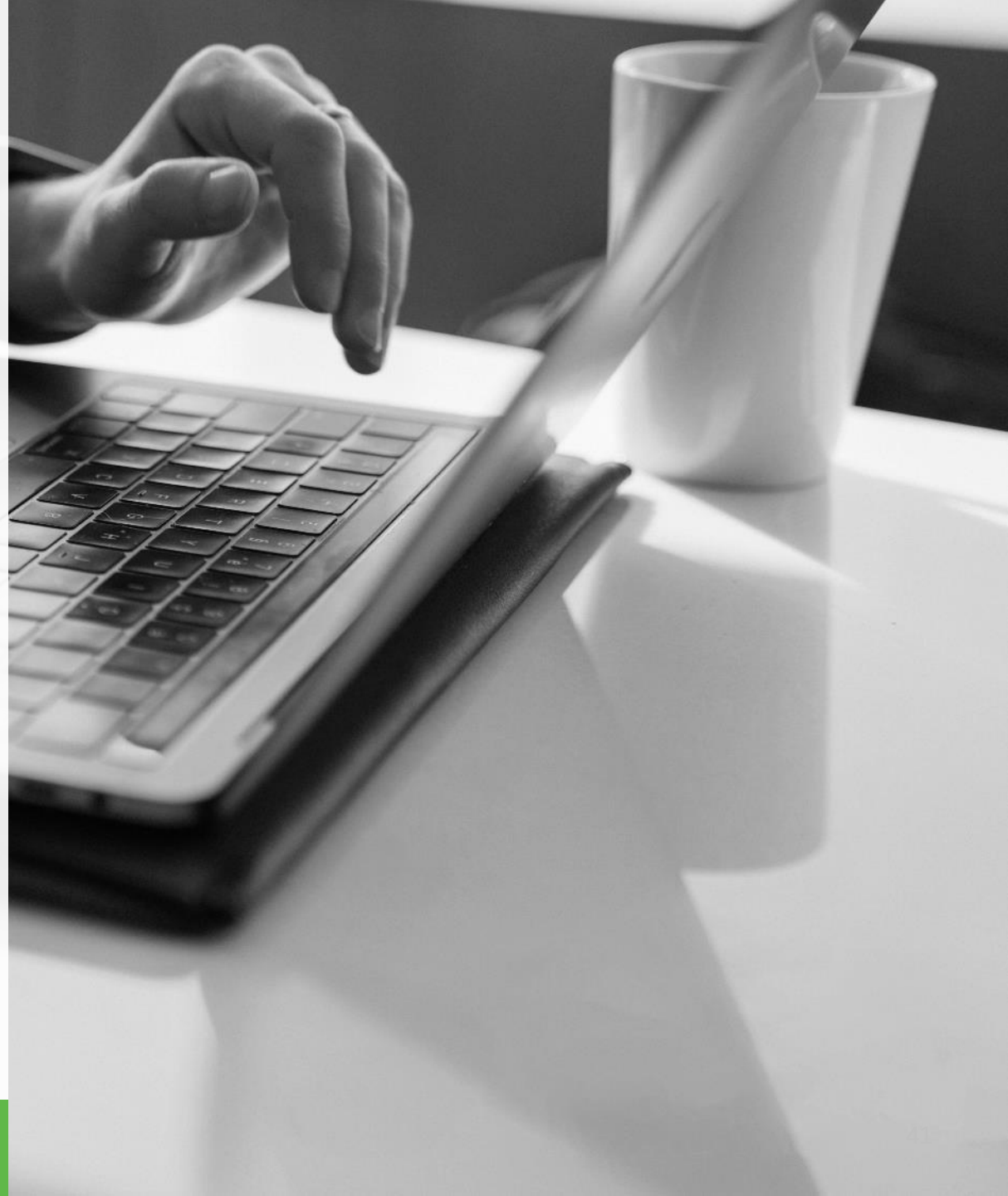
Statewide RSHGC Equation





Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates



Draft Code Change Language – RSHGC Calculation

- **Updated** draft code language for this submeasure is available in the **resources tab.**

$RSHGC = SHGC \times [1 + a \times (e^{-PF} - 1)(\sin(b \times Az) - c)]$

WHERE:

RSHGC = Relative Solar Heat Gain Coefficient.

$SHGC_{win}$ = Solar Heat Gain Coefficient of the vertical fenestration~~window~~.

Az = Azimuth of the vertical fenestration in degrees

PF = Projection factor as calculated by Equation 140.3-D.

	a	b	c
Overhang	0.150	0.130	5.67
Exterior Horizontal Slat	0.144	0.133	5.13

EXCEPTION 2 to Section 130.1(d): Areas adjacent to vertical glazing below an overhang, where the overhang covers the entire width of the vertical glazing, no vertical glazing is above the overhang, and the ~~ratio of the overhang projection to the overhang rise~~ projection factor as calculated by Equation 140.3-D is greater than 1.5 for South, East and West orientations or greater than 1 for North orientations.

Software Updates

- **Current modeling capabilities**
  - Overhangs available but not horizontal slats
  - No modeling of operable blinds
- **Proposed modeling capabilities**
  - Horizontal slats modeled as fixed exterior blinds
  - No change in tilt
  - Always down
  - Defaults to reflectance of 0.70. **Verification burden if we allow other reflectance if they have ASTM E903 test data?**

High Performance Windows

U-factor and SHGC Update

Energy and Cost Impacts: U-factor and SHGC Updates

- Assumptions & Methodology
- Energy Impacts
- Cost Impacts
  - Incremental costs
  - Maintenance costs
  - Energy cost savings
- Cost-effectiveness

Methodology for Energy Impacts Analysis

- Energy modeling was conducted in **EnergyPlus** to evaluate savings per square foot of floor within Energy Commission building prototypes.

	U-factor, SHGC, VT Update
Tools Used	CBECC-Com, EnergyPlus, Excel
Building Prototypes Used	All except for warehouses and hospitals
Climate Zones Modeled	All

Assumptions for Energy Impacts Analysis: High Performance Windows

- Nonresidential building prototypes used to model more stringent envelope thermal factors
  - Warehouse prototypes (refrigerated, non-refrigerated) not included in savings input
- Modeled in all 16 climate zones recognized by the CEC
  - Impacts will vary by climate zone; looking at different requirements for groupings of climate zones
- Period of evaluation for this envelope measure is 30 years

Definition of Baseline and Proposed Conditions: High Performance Windows

Baseline Conditions

- Minimally compliant with 2019 code.

Proposed Conditions

- Minimally compliant with proposed 2022 requirements for U-factor and SHGC, as well as minimally compliant with 2019 code requirements for other window factors.
- The Statewide CASE Team is evaluating different window performance factors across different climate zones.

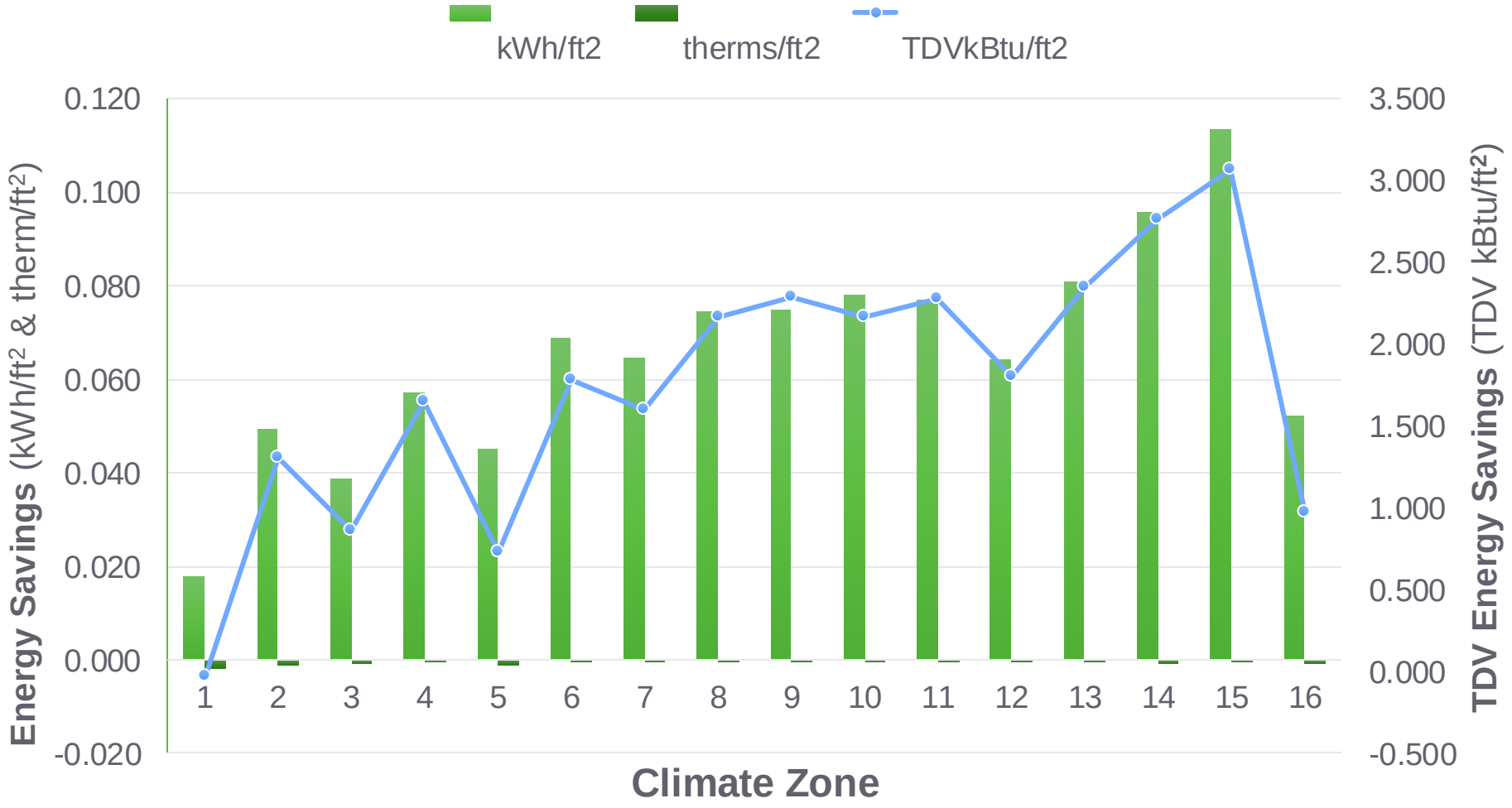
Baseline and Proposed Code Requirements: High Performance Windows

		2019 Title 24, Part 6 Requirements (All Climate Zones)				
			Fixed Window	Operable Window	Curtainwall or Storefront	Glazed Doors[2]
	Area-Weighted Performance Rating	Max U-factor	0.36	0.46	0.41	0.45
		Max RSHGC	0.25	0.22	0.26	0.23
	Area-Weighted Performance Rating	Min VT	0.42	0.32	0.46	0.17
	Maximum WWR%	**40%**				

		2022 Title 24, Part 6 Requirements (All Climate Zones)				
			Fixed Window	Operable Window	Curtainwall or Storefront	Glazed Doors[2]
	Area-Weighted Performance Rating	Max U-factor	0.34	0.46	0.38	0.45
		Max RSHGC	0.22	0.22	0.25	0.23
	Area-Weighted Performance Rating	Min VT	0.42	0.32	0.46	0.17
	Maximum WWR%	**40%**				

Title 24, Part 6. Table 140.3-B B – PRESCRIPTIVE ENVELOPE CRITERIA FOR NONRESIDENTIAL BUILDINGS.

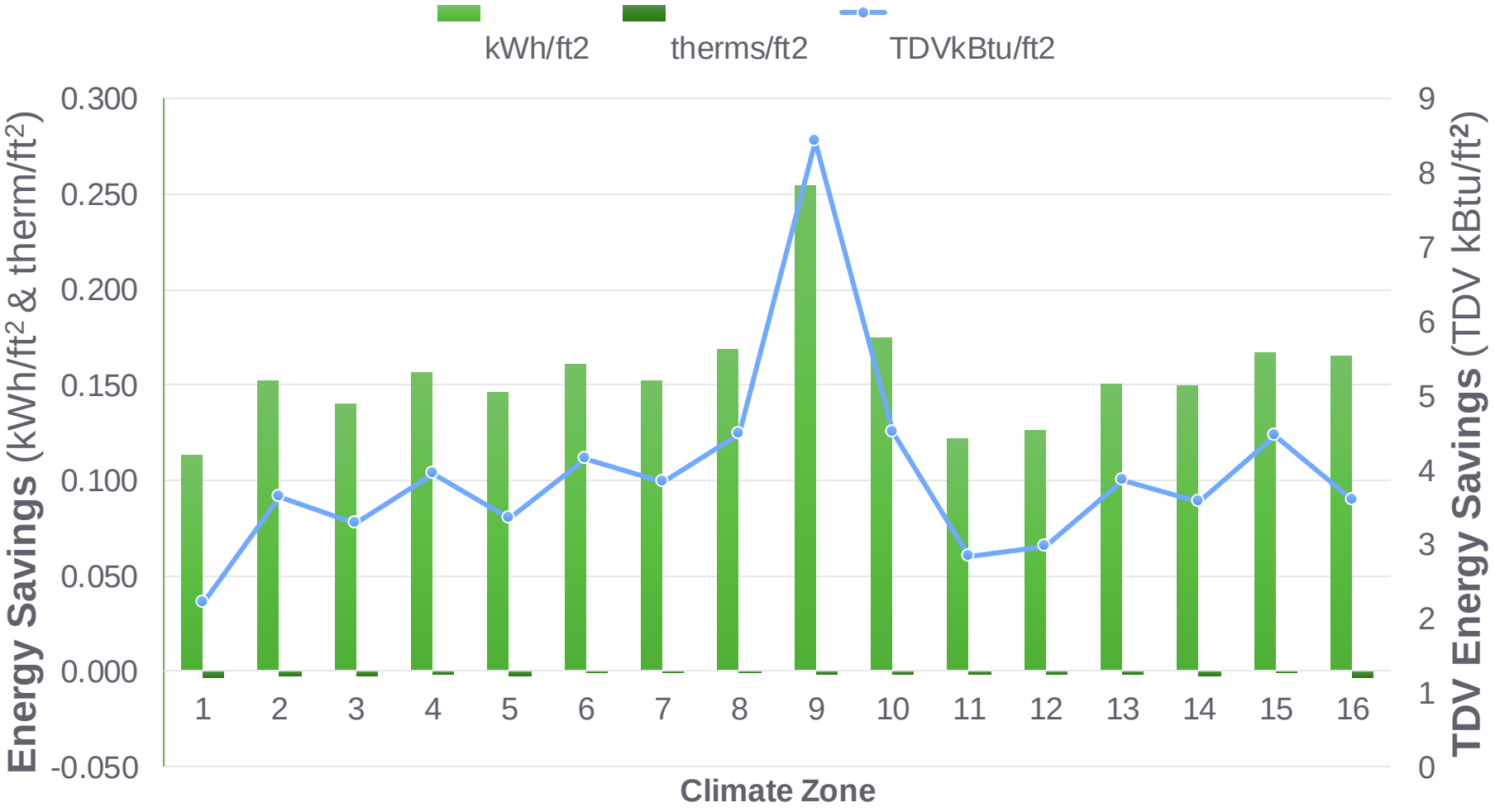
Energy Savings Per Square Foot – Office Medium Lab



The two building types with highest total TDV savings are compared in this presentation.

The OfficeMediumLab prototype has the highest total TDV Savings.

Energy Savings Per Square Foot – Restaurant Fast Food



Climate Zone 9 shows the highest electricity savings for RestaurantFastFood.

Incremental Cost (IMC) Information

- **Collection of costs of base case technology and proposed technology**
  - Interviews with manufacturers, distributors, and suppliers to collect over 50 data points
  - Industry-led studies on window cost
  - Other sources were reviewed but found not to contain relevant content
    - Online prices from retailer
    - Existing California-based cost-effectiveness studies
- **Cost includes all related costs: materials, construction, and labor**
  - Higher labor costs associated with heavier window products such as triple pane
  - Maintenance labor is not relevant and therefore not included
  - Labor costs were averaged for urban/non-urban areas

Incremental Per Unit Cost

Over 30 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Equipment ($ per square foot of window surface area)	$2.00	Equipment Replacement	N/A
Labor	N/A	Annual Maintenance	N/A

- Window costs include **overhead and profit costs.**
- High performance window technologies that were evaluated for cost in any combination: fourth surface low-e coating, double-silver on green tint, triple pane with single-silver second surface, warm edge spacers, double pane, thermally broken frames.

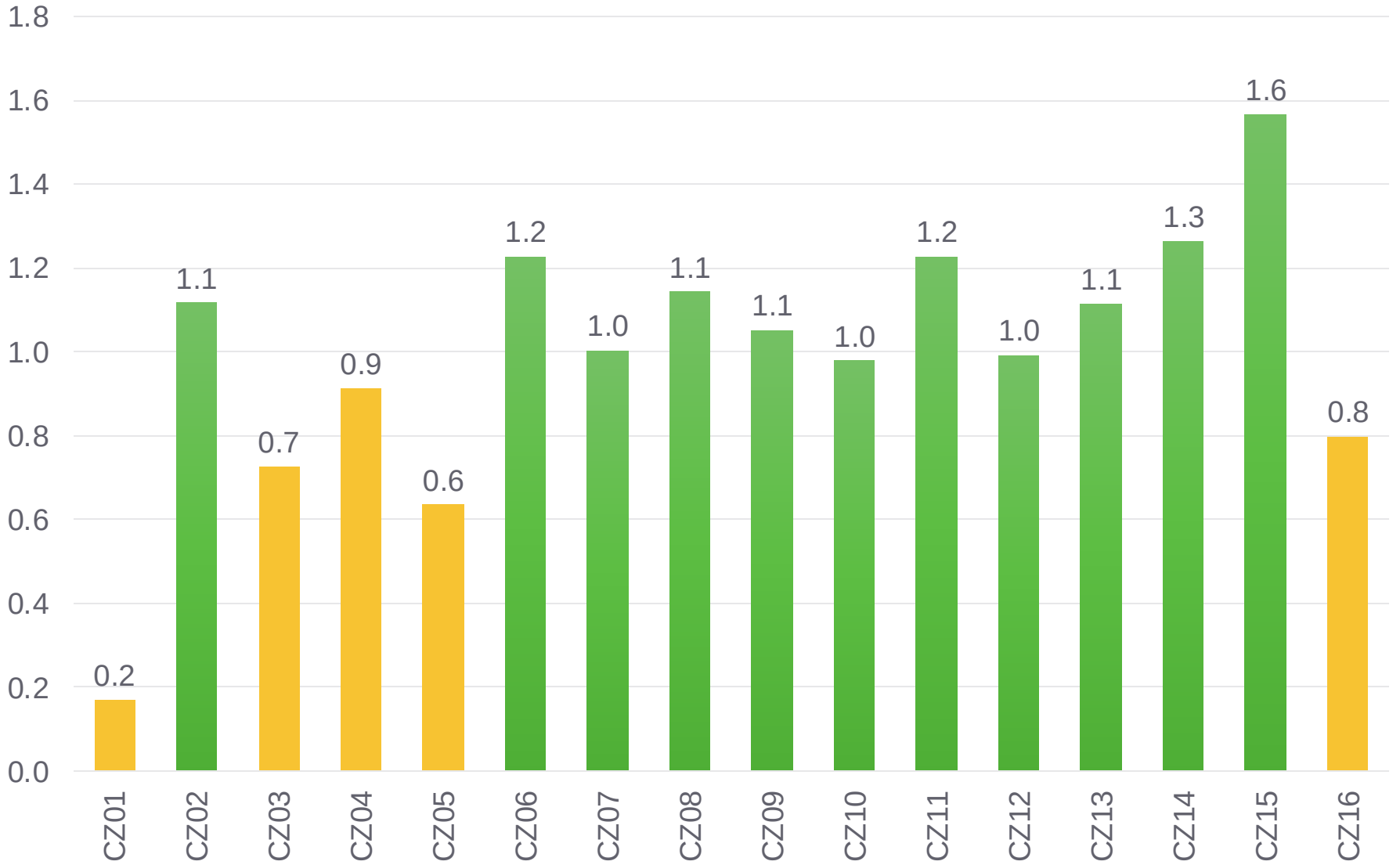
What are your reactions to these costs?

Incremental Per Unit Cost

Over 30 Year Period of Analysis

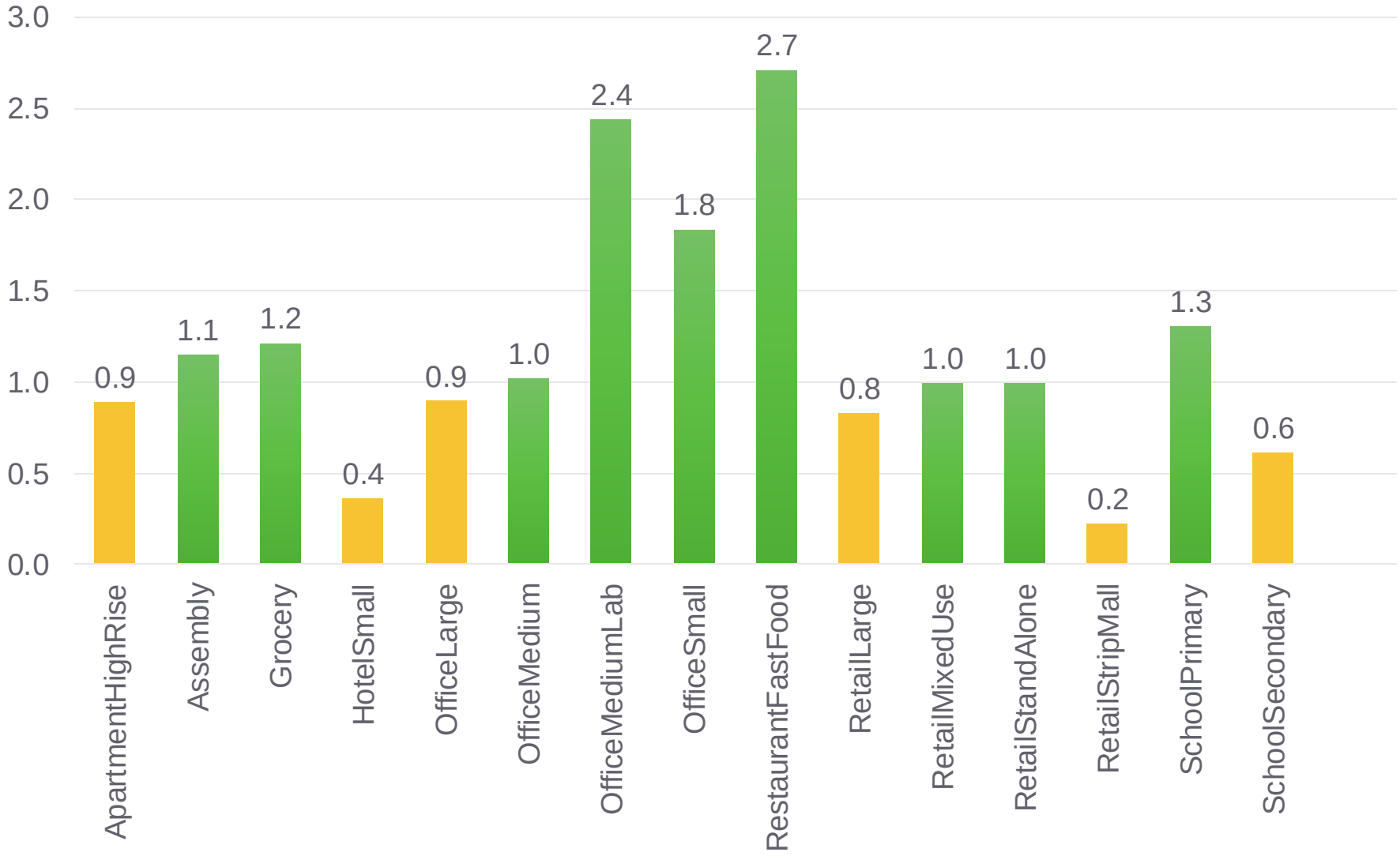
Building Prototype	Window Area (ft^2)	Total Cost	Building Area (ft^2)	Total Cost per Square Foot of Building Area ($/$ft^2$)
ApartmentHighRise	11,825	$23,650	93,632	$0.25
Assembly	1,051	$2,102	34,007	$0.06
Grocery	1,587	$3,174	50,002	$0.06
HotelSmall	1,983	$3,966	42,554	$0.09
OfficeLarge	48,134	$96,268	498,589	$0.19
OfficeMedium	7,027	$14,054	53,628	$0.26
OfficeMediumLab	7,027	$14,054	53,628	$0.26
OfficeSmall	642	$1,285	5,502	$0.23
RestaurantFastFood	280	$560	2,501	$0.22
RetailLarge	5,881	$11,761	240,000	$0.05
RetailMixedUse	558	$1,116	9,375	$0.12
RetailStandAlone	904	$1,807	24,563	$0.07
RetailStripMall	558	$1,116	9,375	$0.12
SchoolPrimary	4,964	$9,928	24,413	$0.41

Benefit-to-Cost Ratio by Climate Zone



Average value of benefit-to-cost ratio is **1.0.**

Benefit-to-Cost Ratio by Building Type



Submeasure is most cost effective for OfficeMediumLab and RestaurantFastFood.

2023 Construction Forecast: New Construction - High Performance Windows

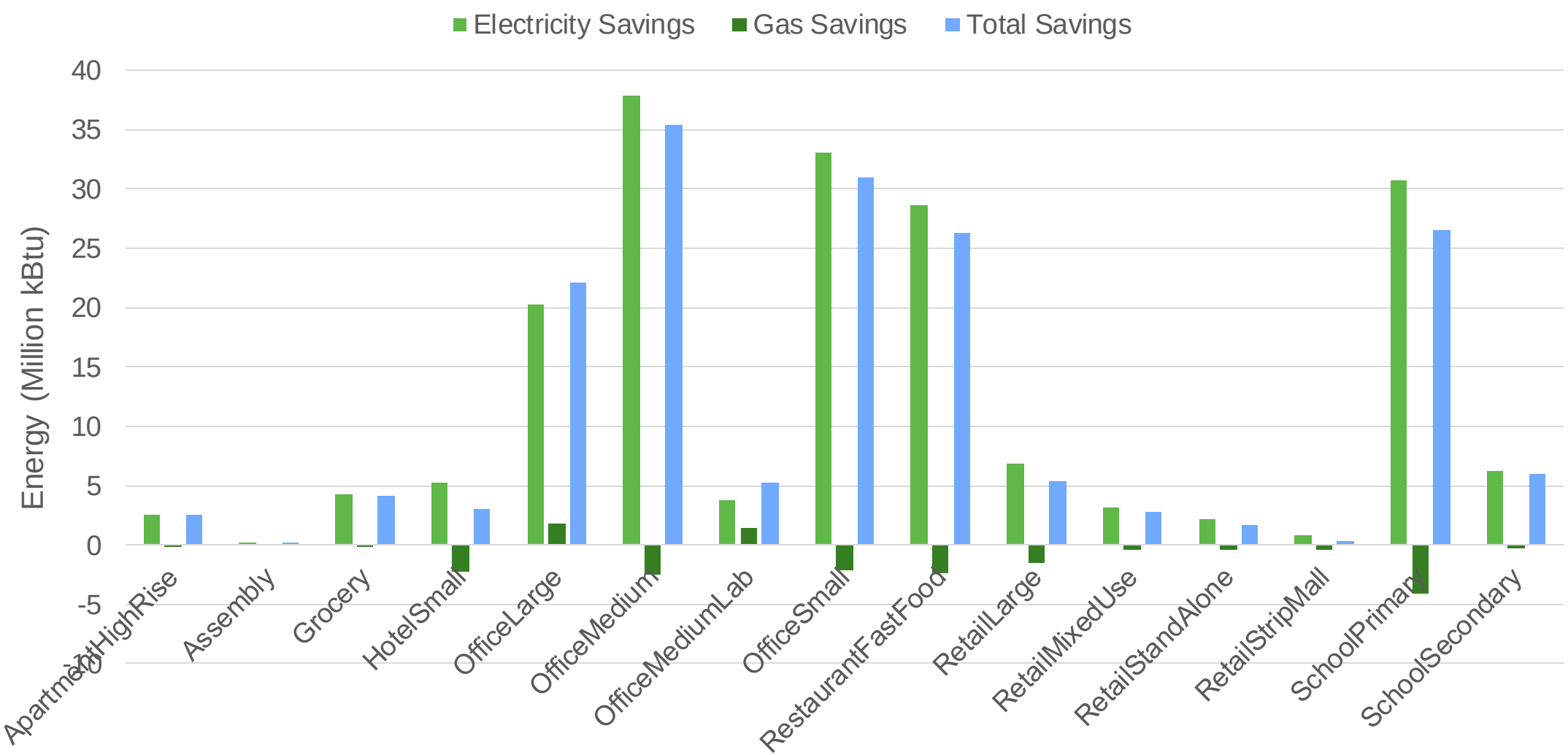
Building Type	Total Statewide New Construction Permitted in 2023 (million square feet)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (million square feet)
Nonresidential	161	95.2%	153.4

- **Warehouses** are dominated by heating and therefore are not included in the modeling.
- **Hotels and motels** exhibit lack of savings from 24/7 occupancy loads.

Statewide First-Year TDV Savings by Climate Zone (New Construction)

172.5 Million TDV kBtu/yr will be saved from New Construction

Statewide First-Year TDV Savings by Building Type (New Construction)



Thank You

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Submeasure A: High Performance Windows

Submeasure B: Opaque Envelope

Submeasure C: Roof Alterations

Submeasure D: Cool Roofs

Methodology for Energy Impacts Analysis: Opaque Envelope

- Energy modeling was conducted in **EnergyPlus** to evaluate savings per square foot within Energy Commission building prototypes.

Tools Used	CBECC-Com, EnergyPlus, Excel
Building Prototypes Used	All nonresidential prototypes
Climate Zones Modeled	All

Assumptions for Energy Impacts Analysis: Opaque Envelope

- Nonresidential building prototypes were used to model more stringent envelope assembly U-factors.
- Modeled in **all 16 climate zones**:
  - Impacts will vary by climate zone; looking at different requirements for different groupings of climate zones.
- Period of evaluation for this envelope measure is **30 years**.

Definition of Baseline and Proposed Conditions
Opaque Envelope

Baseline Conditions

- Minimally compliant with 2019 Title 24, Part 6 requirements.

Proposed Conditions

- Minimally compliant with proposed assembly U-factor values for 2022 Title 24, Part 6 in addition to 2019 requirements.

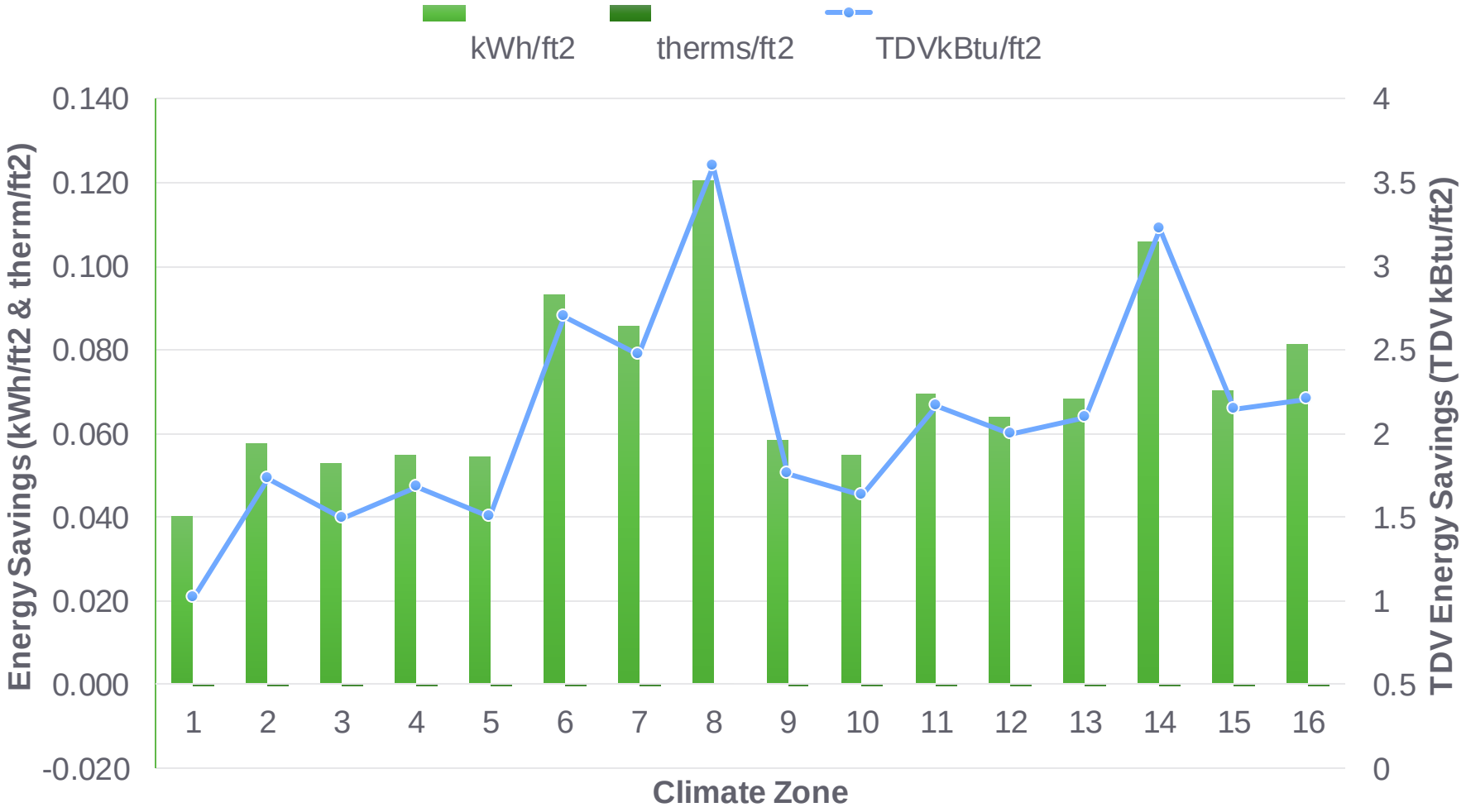
Baseline and Proposed Code Requirements

	Roofs/Ceilings: Wood Framed and Other		Walls: Metal-framed		
Baseline U-Factor	0.034	0.049	0.062	0.069	0.082
Proposed U-Factor	0.030	0.043	0.055	0.060	0.071
Climate Zones Impacted	1-5, 9-16	6-8	2, 4, 5, 8-16	1, 6, 7	3

Energy and Cost Impacts: Opaque Envelope - Roof

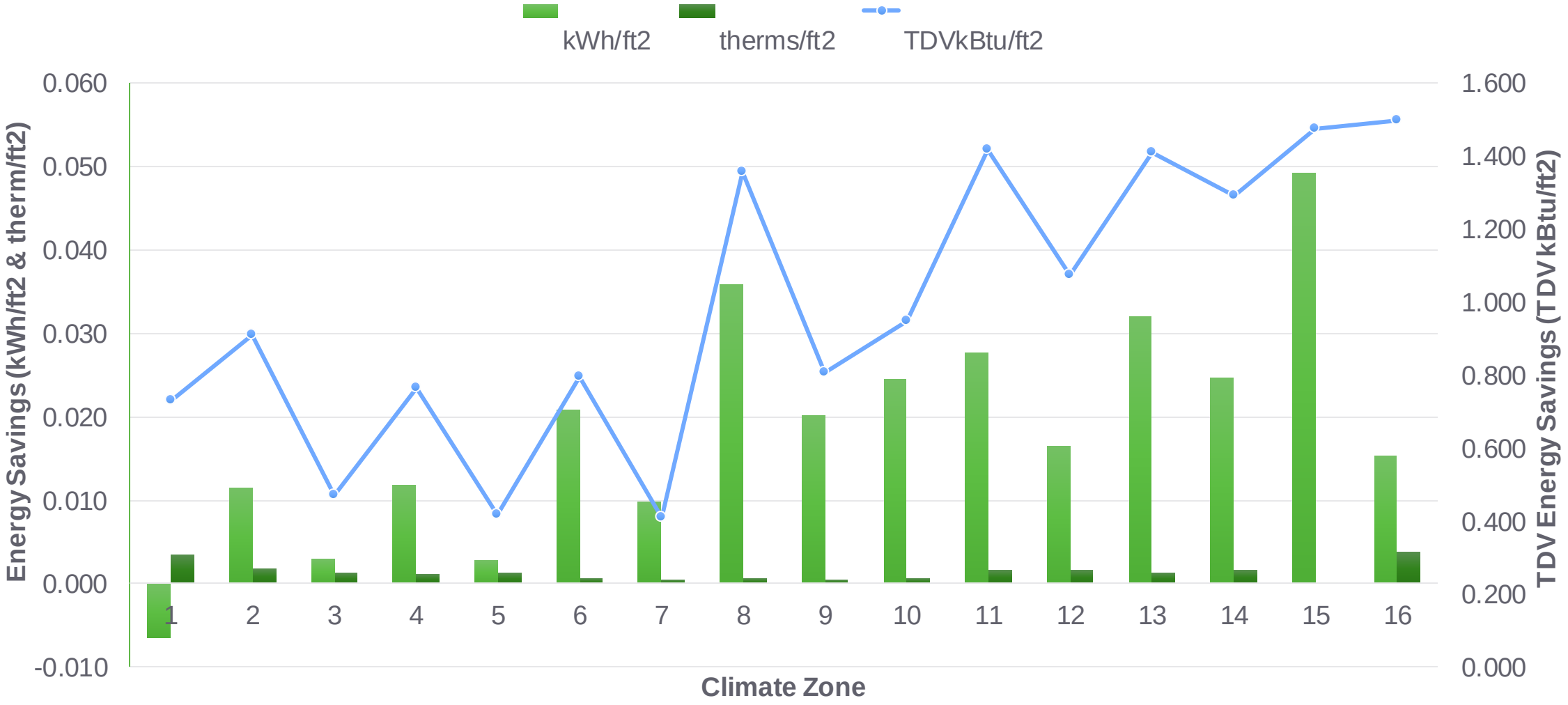
- Per Unit Energy Impacts
- Cost Impacts
  - Incremental costs
  - Maintenance costs
  - Energy cost savings
- Cost-effectiveness
- Statewide Energy Savings

Energy Savings Per Square Foot – Grocery



Gas savings are negative across all climate zones for Grocery prototype.

Energy Savings Per Square Foot – OfficeSmall



Incremental Cost Information

- **Includes cost of base case technology vs proposed technology:**
  - Based on previous opaque envelope CASE reports
  - Gathered from current market
  - RS Means
  - Discussed in interviews with industry stakeholders
- **Product cost differences included**
  - Labor and maintenance costs were assumed to remain the same
  - Additional thickness of insulation required to meet lower U-factors

Incremental Per Unit Cost

Over 30 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
Per Roof	$3,835.67	Equipment Replacement	N/A
Per Building Square Foot	$0.0077	Annual Maintenance	N/A

- Insulation costs include overhead and profit costs
- Cost associated with each R-value is the cost for an approximate range that includes respective R-value
- Submeasure evaluates increase of cost when adding additional R-4 to baseline continuous layer

$ 0.008

Final incremental cost – per building square foot.

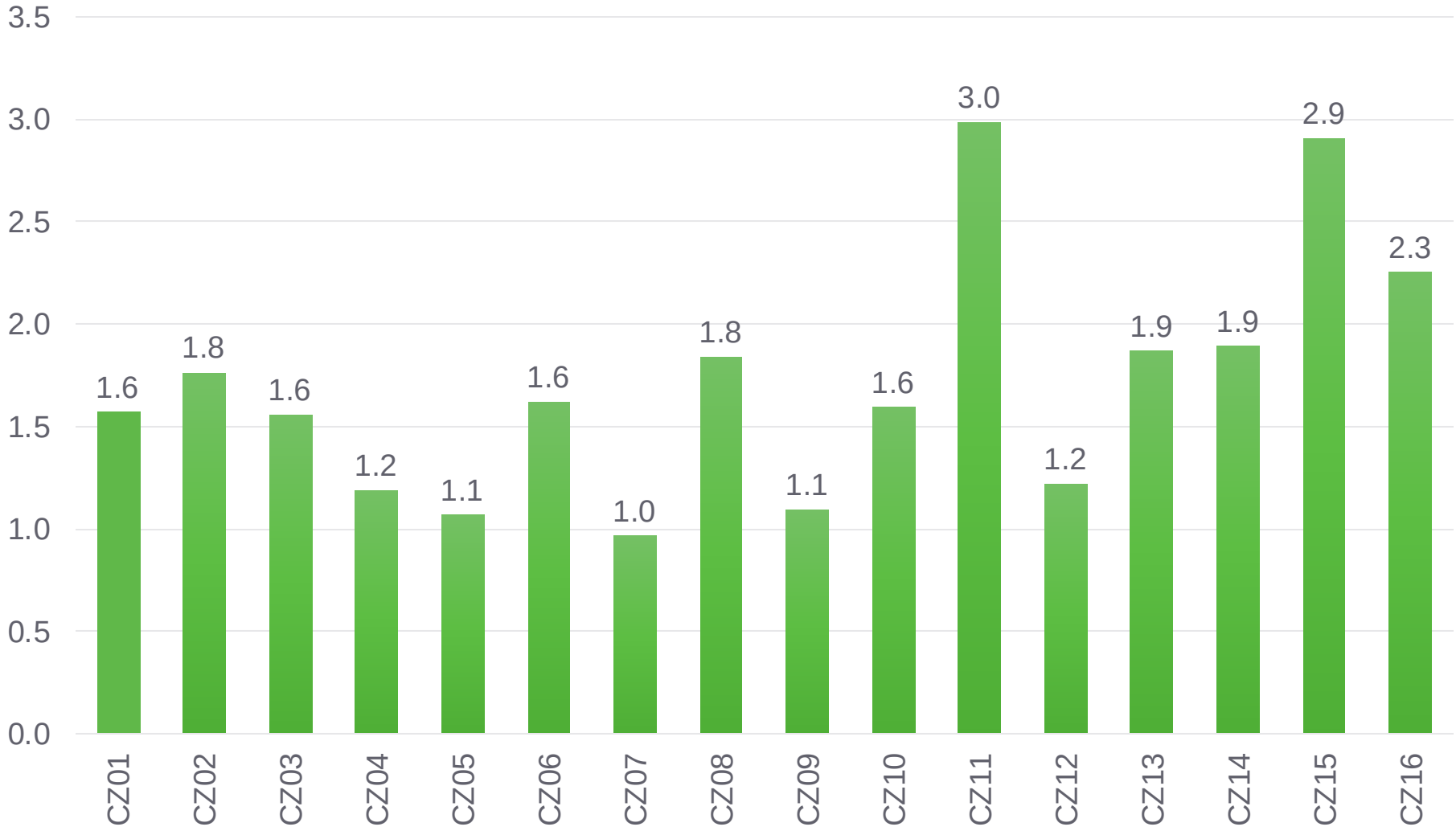
What are your reactions to these costs?

Incremental Per Unit Cost

Over 30 Year Period of Analysis

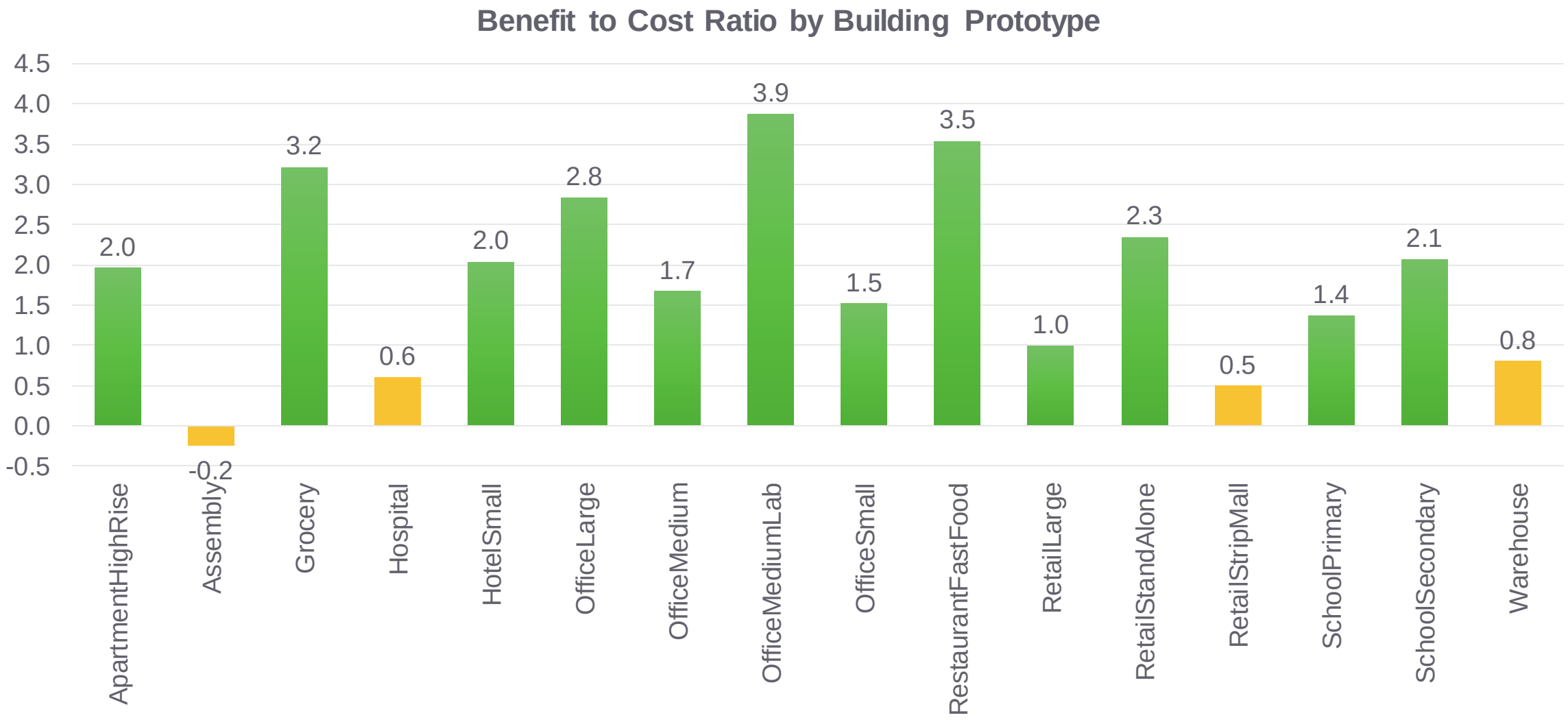
Building Prototype	Net Roof Area (ft^2)	Total Cost	Building Area (ft^2)	Total Cost per Square Foot of Building Area ($/$ft^2$)
ApartmentHighRise	8,512	$851	93,632	$0.01
Assembly	34,007	$3,401	34,007	$0.10
Grocery	50,002	$5,000	50,002	$0.10
Hospital	83,331	$8,333	249,985	$0.03
HotelSmall	10,802	$1,080	42,554	$0.03
OfficeLarge	38,357	$3,836	498,589	$0.01
OfficeMedium	17,878	$1,788	53,628	$0.03
OfficeMediumLab	17878.68	$1,788	53,628	$0.03
OfficeSmall	5502	$550	5,502	$0.10
RestaurantFastFood	2,501	$250	2,501	$0.10
RetailLarge	240000	$24,000	240,000	$0.10
RetailStandAlone	24563	$2,456	24,563	$0.10
RetailStripMall	9,375	$938	9,375	$0.10
SchoolPrimary	24413	$2,441	24,413	$0.10
SchoolSecondary	122,184	$12,218	210,866	$0.06
Warehouse	49495	$4,950	49,495	$0.10

Benefit-to-Cost Ratio by Climate Zone



Average value of cost effectiveness is **1.7.**

Benefit-to-Cost Ratio by Building Type

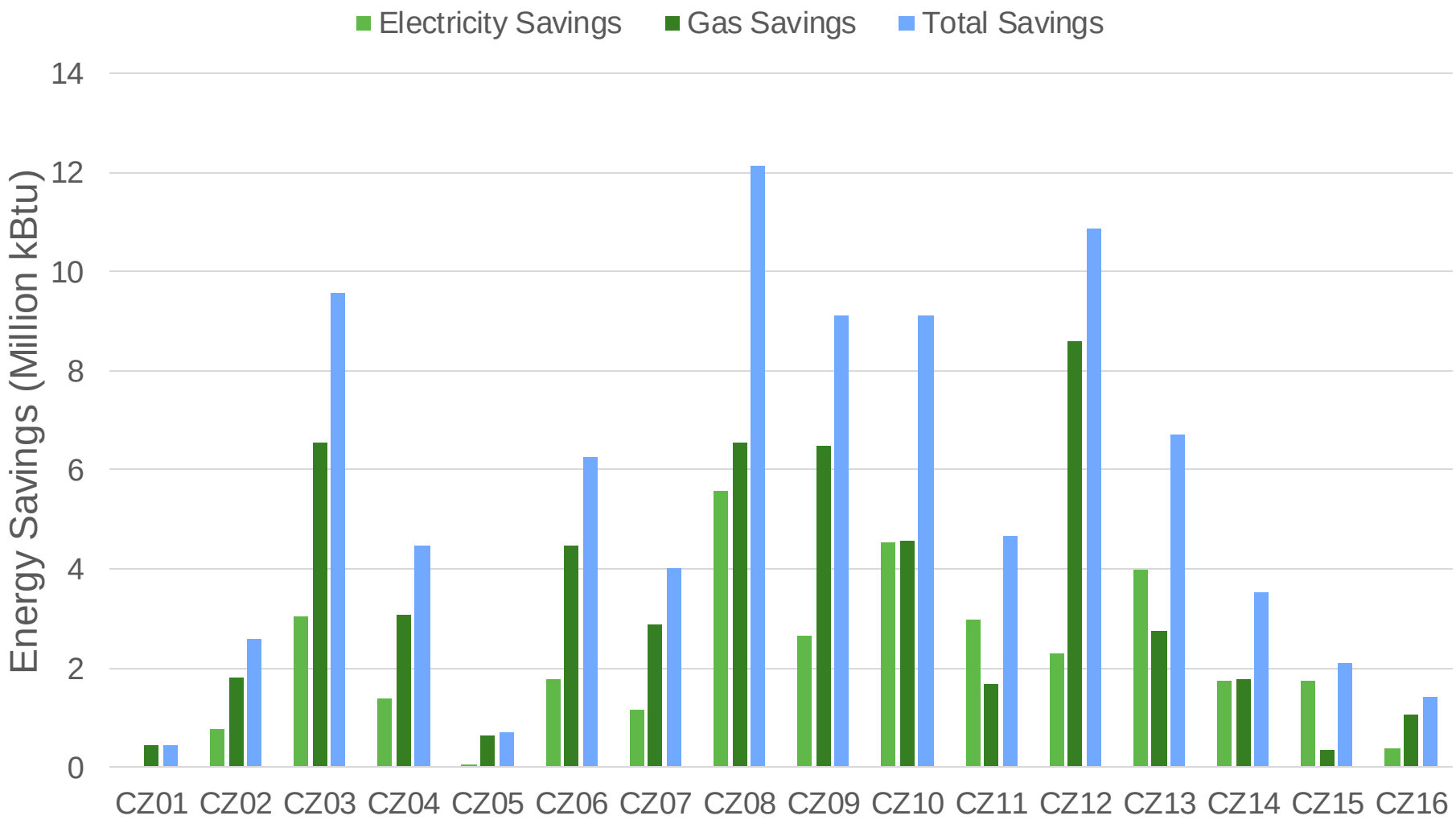


2023 Construction Forecast: New Construction

Building Type	Total Statewide New Construction Permitted in 2023 (million ft^2)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (million ft^2)
Nonresidential	161	100%	161

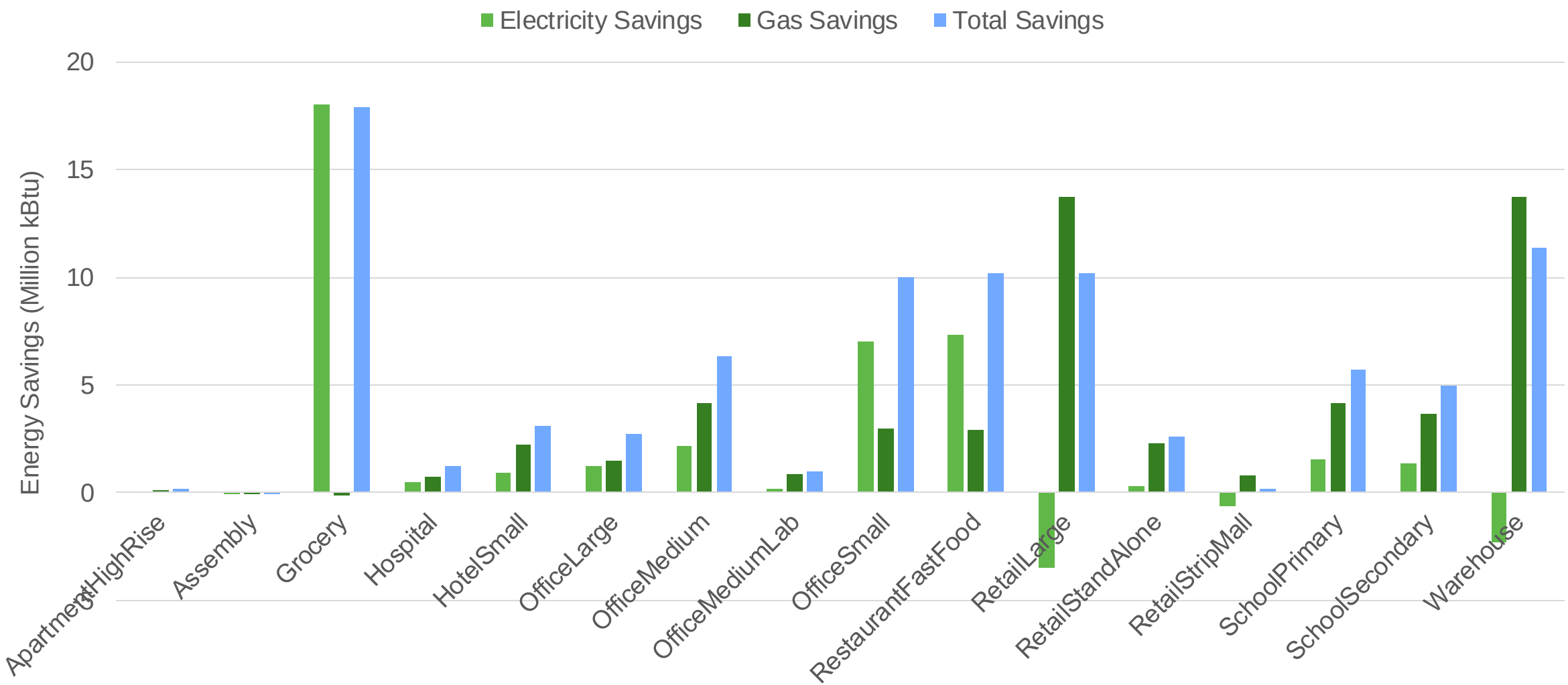
- All building prototypes in all climate zones are evaluated for this submeasure.

Statewide First-Year TDV Savings by Climate Zone (New Construction)



87.68 Million TDV kBtu/yr will be saved from New Construction

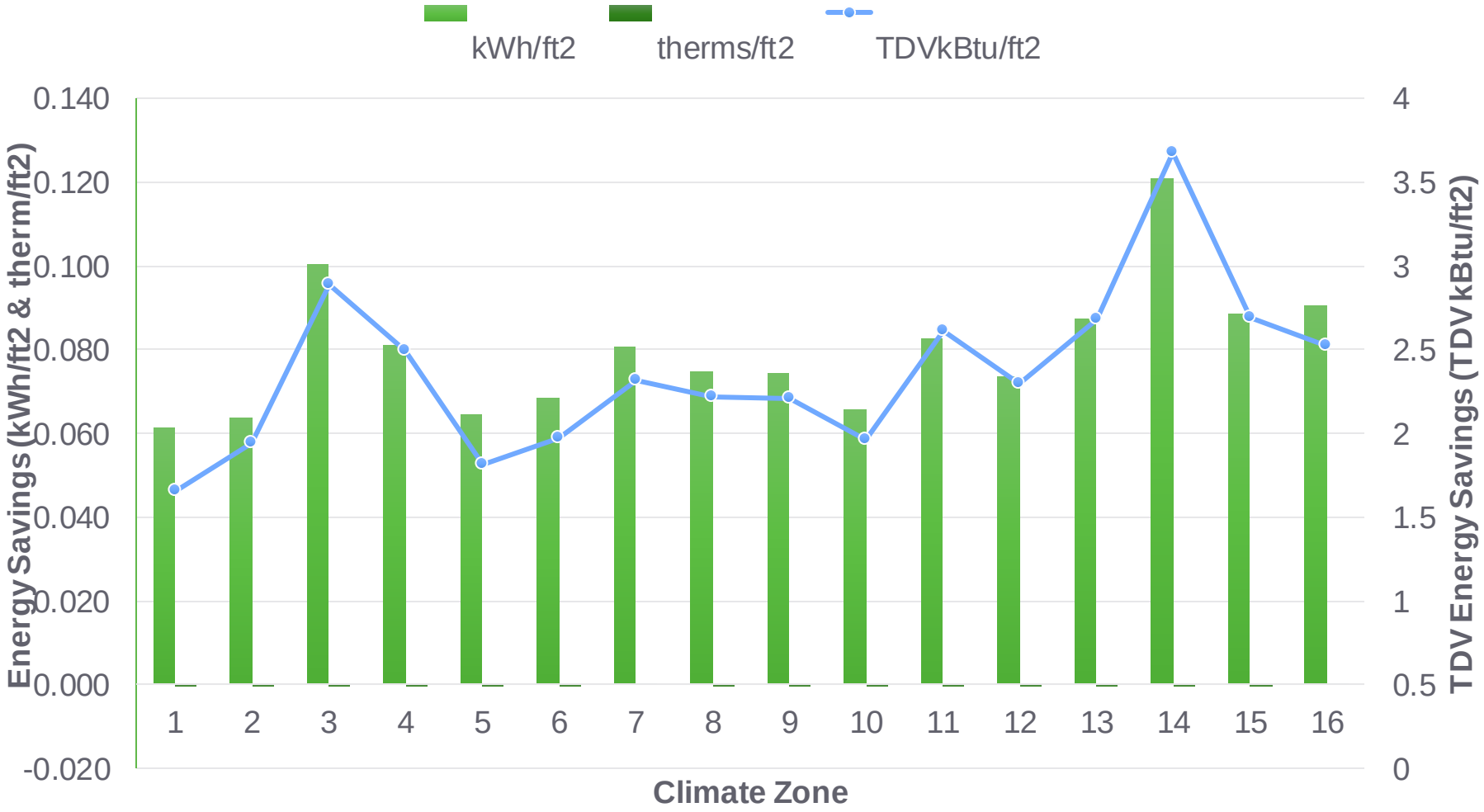
Statewide First-Year TDV Savings by Building Type (New Construction)



Energy and Cost Impacts: Opaque Envelope - Wall

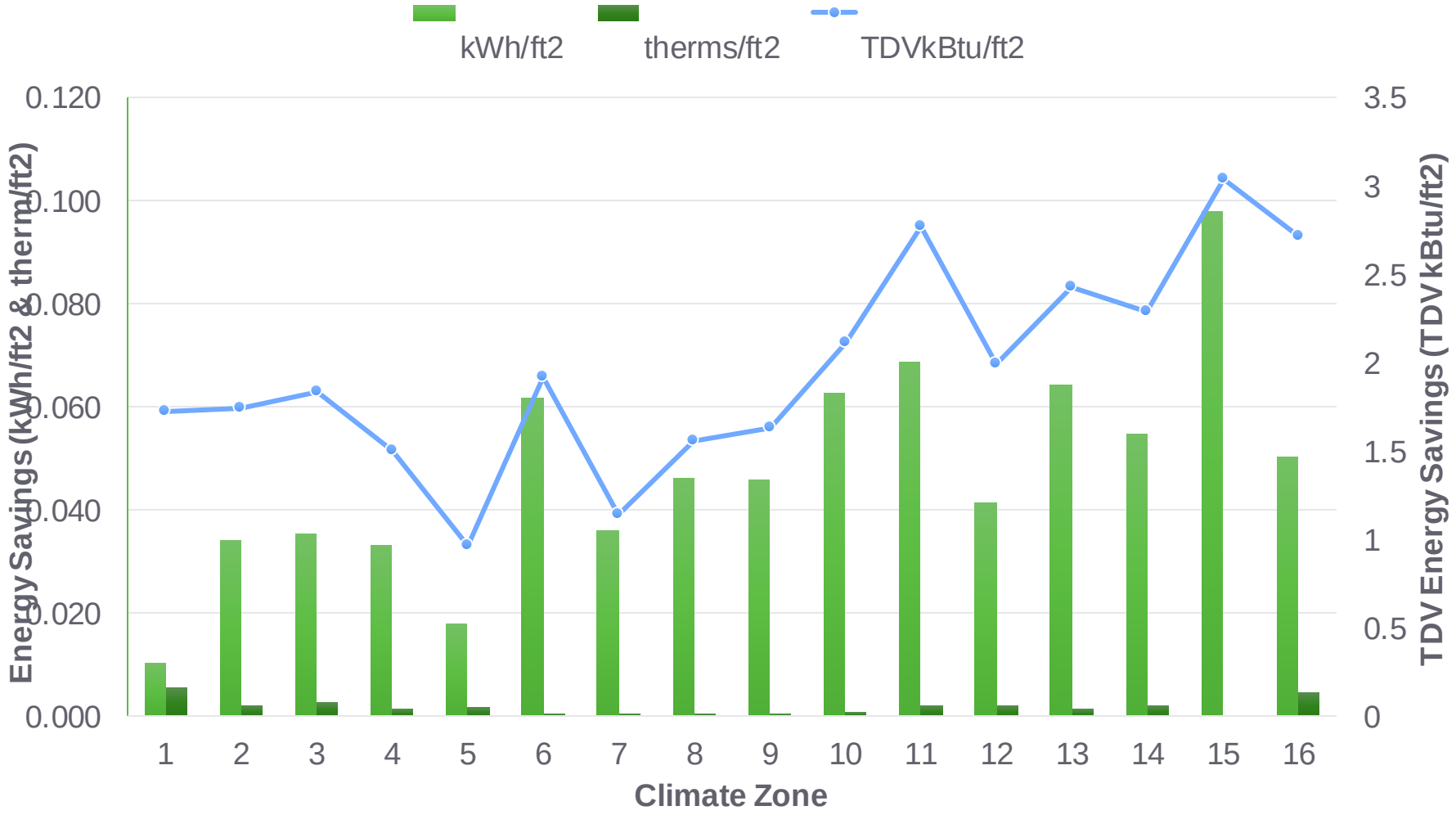
- Per Unit Energy Impacts
- Cost Impacts
  - Incremental costs
  - Maintenance costs
  - Energy cost savings
- Cost-effectiveness
- Statewide Energy Savings

Energy Savings Per Square Foot – Grocery



Gas savings are small but positive across all climate zones.

Energy Savings Per Square Foot – Office Small



Climate Zone 15 shows the highest savings for Office Small.

Incremental Cost Information

- **Includes cost of base case technology vs proposed technology:**
  - Based on previous opaque envelope CASE Reports
  - RS Means
  - Gathered from current market
  - Discussed in interviews with industry stakeholders
- **Product cost differences included:**
  - Labor and maintenance costs were assumed to remain the same
  - Thicker insulation to meet lower U-factor requirements

Incremental Per Unit Cost

Over 30 Year Period of Analysis

Incremental First Cost		Incremental Maintenance Cost	
For Entire Wall	$4,462.21	Equipment Replacement	N/A
Per Square Foot	$0.0089	Annual Maintenance	N/A

- Insulation costs include overhead and profit costs
- Cost associated with each R-value is the cost for an approximate range that includes respective R-value
- Submeasure evaluates increase of cost when adding additional R-4 to baseline continuous layer

$ 0.0089

Final incremental cost – per building square foot.

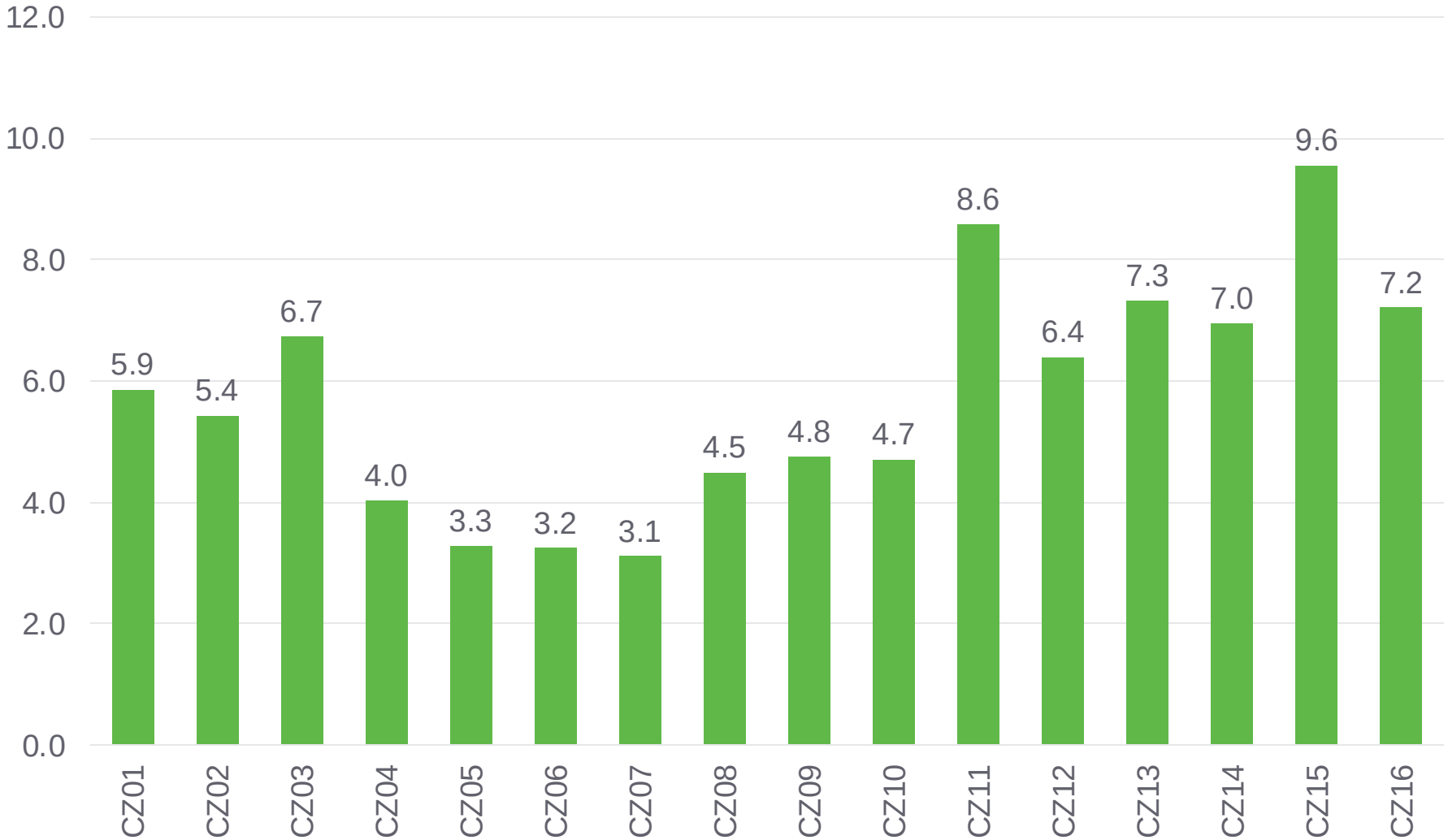
What are your reactions to these costs?

Incremental Per Unit Cost

Over 30 Year Period of Analysis

Building Prototype	Net Wall Area (ft^2)	Total Cost	Building Area (ft^2)	Total Cost per Square Foot of Building Area ($/ft^2$)
ApartmentHighRise	35,579	$3,558	93,632	$0.04
Assembly	9,211	$921	34,007	$0.03
Grocery	20,775	$2,078	50,002	$0.04
Hospital	36,223	$3,622	249,985	$0.01
HotelSmall	16,259	$1,626	42,554	$0.04
OfficeLarge	76,600	$7,660	498,589	$0.02
OfficeMedium	14,262	$1,426	53,628	$0.03
OfficeMediumLab	14262	$1,426	53,628	$0.03
OfficeSmall	2388	$239	5,502	$0.04
RestaurantFastFood	1,721	$172	2,501	$0.07
RetailLarge	44124	$4,412	240,000	$0.02
RetailMixedUse	4966	$497	9,375	$0.05
RetailStandAlone	11767	$1,177	24,563	$0.05
RetailStripMall	6,241	$624	9,375	$0.07
SchoolPrimary	8988	$899	24,413	$0.04
SchoolSecondary	42,083	$4,208	210,866	$0.02
Warehouse	26690	$2,669	49,495	$0.05

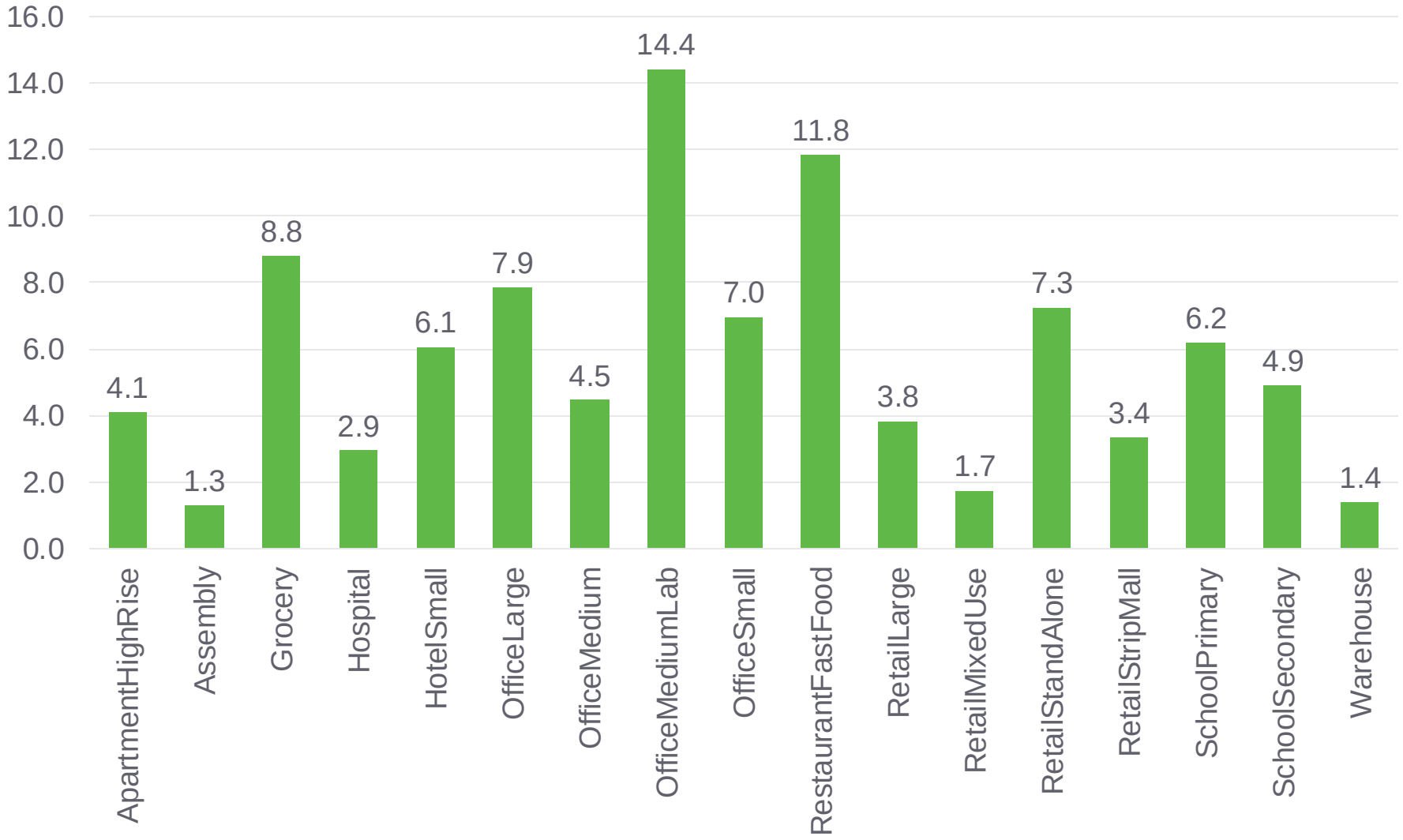
Benefit-to-Cost Ratio by Climate Zone



Average value of cost effectiveness is **5.73.**

BC Ratio is over 1 for all climate zones.

Benefit-to-Cost Ratio by Building Type



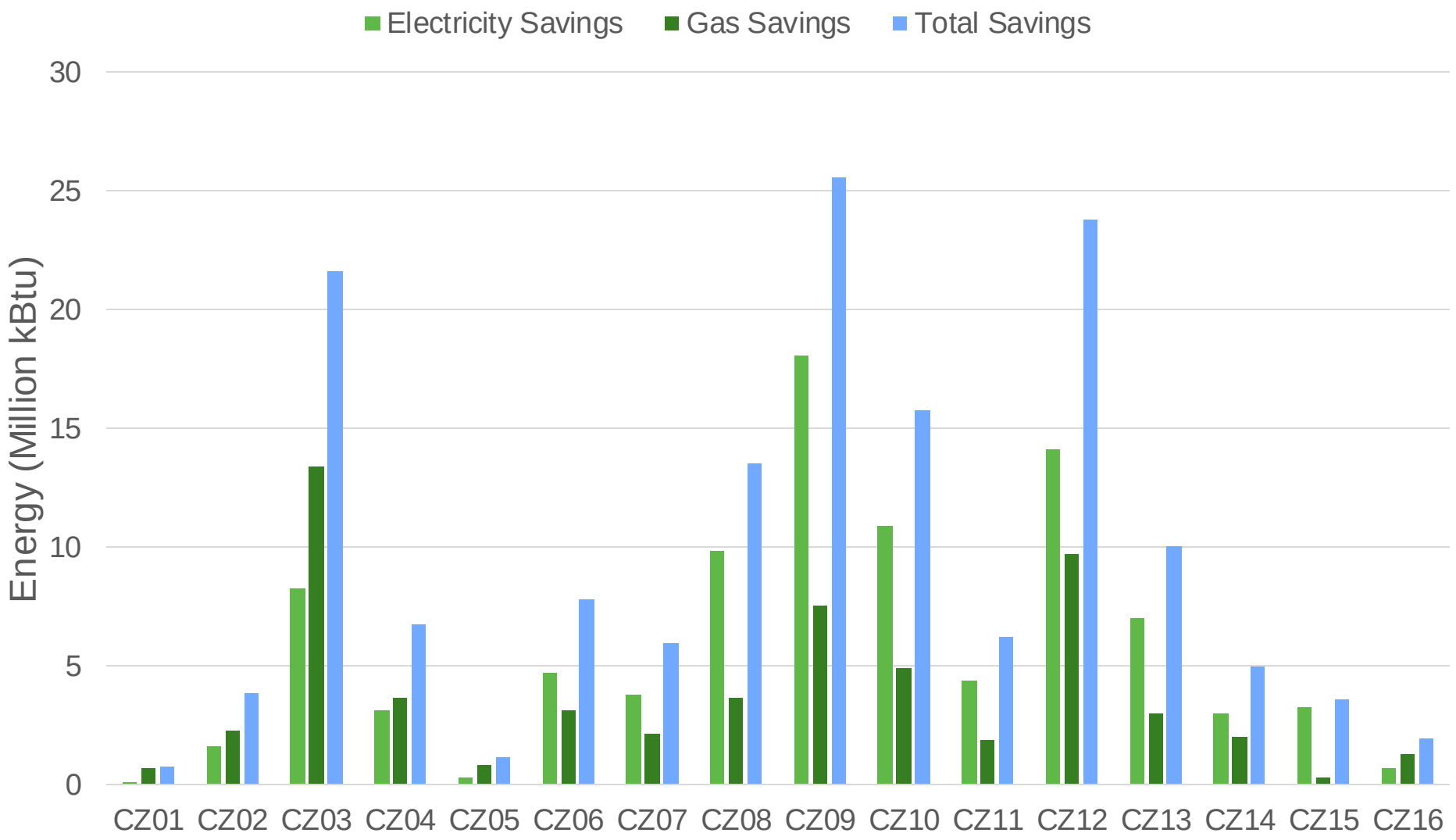
Submeasure is most cost effective for OfficeMediumLab.

2023 Construction Forecast: New Construction

Building Type	Total Statewide New Construction Permitted in 2023 (million ft^2)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (million ft^2)
Nonresidential	161	100%	161

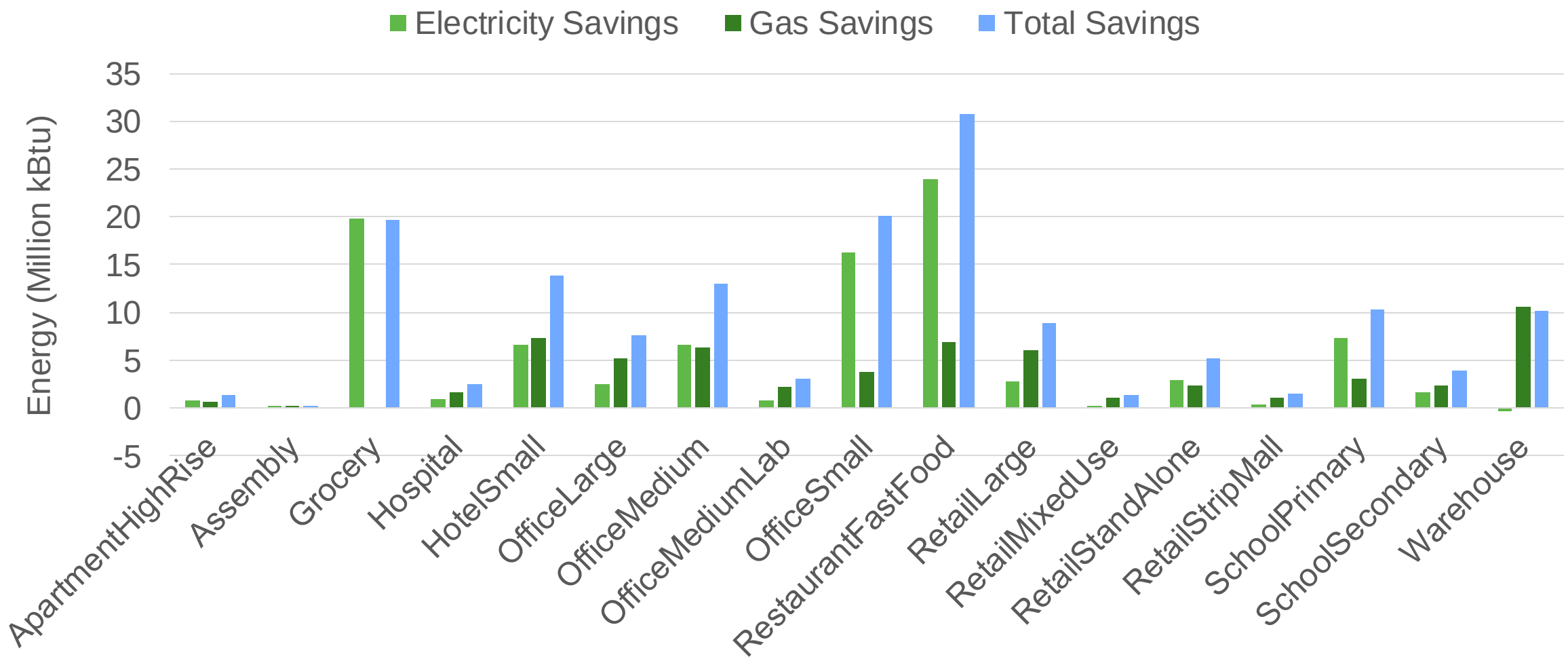
- All building prototypes in all climate zones are evaluated for this submeasure

Statewide First-Year TDV Savings by Climate Zone (New Construction)



153.2 Million TDV kBtu/yr will be saved from New Construction

Statewide First-Year TDV Savings by Building Prototype (New Construction)



Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Submeasure A: High Performance Windows

Submeasure B: Opaque Envelope

Submeasure C: Roof Alterations

Submeasure D: Cool Roofs

Code Change Proposal Summary: Roof Alterations

Update	Type of Change	Software Updates Required	Sections of Code Updated	Compliance Documents Updated	Compliance Manual Updates
Roof Alterations	Prescriptive	Yes	100.1 141.0(b)2Biii	NRCC-ENV-E	3.6.2.2

Description of Changes

- Update insulation requirements for roof alterations to align with new construction
- Adds insulation requirements for roof recovers
- Modifies the exceptions for base flashing height
  - Only applies when in certain climate zones if below deck is inaccessible for adding insulation.

Code Change Proposal Summary

1. Insulation requirements

Current

Climate zone	Insulation Required
1, 3-9	R-8 or U-0.082
2, 10-16	R-14 or U-0.055

Roof recovers: exempt

Proposed

Climate zone	Insulation Required
6-8	U-0.049
1-5, 9-16	U-0.034

Roof recovers: R-8 minimum

Other than insulation lifetime, what else should the Statewide CASE Team consider when evaluating insulation for roof recovers?

Code Change Proposal Summary

2. Exceptions

Current

1. Existing R-7
2. Mechanical equipment is not lifted as part of the alteration, may limit the insulation to allow 8” base flashing height (BFH)
3. If adding insulation will reduce the BFH to less than 8” at penthouse or parapet walls and:
    1. Has an exterior cladding material other than the roofing covering membrane material; and
    2. The exterior cladding must be removed to maintain BFH of 8”
    3. Below the ratio of replaced roof area to linear dimensions of affected wall
4. Tapered insulation may be used.

Proposed

1. Roof recovers shall be insulated to at least R-8
2. Only applies to CZ 3-9 if the ceiling is not accessible for adding insulation
3. Removed
4. Unchanged

Base Flashing Height Examples

Poll

Should a minimum of an inch of insulation above deck be required regardless of the existing conditions?

A. Yes (please explain)
B. No (please explain)

Requirements in IECC and ASHRAE 90.1 - New and Alterations

National Climate Zone	IECC – 2018	ASHRAE 90.1 – 2019
2	R-25ci, R-38 below deck	R-25ci (U-0.039), R-38 (U-0.027) below deck
3	R-25ci, R-38 below deck	R-25ci (U-0.039), R-38 (U-0.027) below deck
4	R-30ci, R-38 below deck	R-30ci (U-0.032), R-49 (U-0.021) below deck

Exceptions in IECC

- Existing ceiling cavities exposed during construction if filled with insulation
- Roof recover
- Construction where the existing roof cavity is not exposed

Exceptions in ASHRAE 90.1

- Roof alterations insulated to full depth with R-3.0/in.
- Roof recovering
- Removal and replacement of a roof membrane where there is existing roof insulation integral to or below the roof deck

Energy and Cost Impacts

- Assumptions & Methodology
- Energy Impacts
- Cost Impacts
  - Incremental costs
  - Maintenance costs
  - Energy cost savings
- Cost-effectiveness

Methodology for Energy Impacts Analysis

- Energy modeling was conducted in **EnergyPlus** to determine savings for all Energy Commission building prototypes.
- The roof insulation levels were adjusted for buildings compliant with 2019 code.

Tools Used	CBECC simulation, EnergyPlus, spreadsheet
Building Prototypes Used	All nonresidential
Climate Zones Modeled	Impacts calculated for all climate zones

Assumptions for Energy Impacts Analysis

- Using a **30-year level** of analysis, nonresidential buildings were modeled with roof insulation updated to new construction levels.
- **Steep slope roofs were excluded**
- Roof cover lifetimes were estimated at 17 years, based on the 2010 BOMA Preventative Maintenance Guidebook[1]
- Roofs were estimated to be recovered 50% of the time and replaced 50% of the time after 17 years
- Energy impacts were analyzed for buildings with existing **R-7 and R-14**.

1. Shoen, Lawrence. 2010. *Preventive Maintenance Guidebook- Best Practices to Maintain Efficient and Sustainable Buildings.* Building Owners and Managers Association International.

Existing roof insulation assumptions

Existing insulation:

1. No requirement before 1979
2. 2005 new construction prescriptive requirement (17 years before 2022):
    1. CZ 1-5, 10-16 -> R-19
    2. CZ 6-9 -> R-11
3. Before 2008 code, insulation was often traded off
4. National survey found an average R-value of 12.4 for buildings built after 1980[2]

2. Phelan, Jerry, George Pavlovich, and Eric Ma. 2009. Energy and Environmental Impact Reduction Opportunities for Existing Buildings with Low-Slope Roofs. Communications Department of Bayer MaterialScience.

Existing roof insulation assumptions

Existing prescriptive requirements:

1. R-8 for CZ 1, 3-9
2. R-14 for CZ 2, 10-16
3. Exception for R-7
4. Exception for recovers
5. Exception for mechanical equipment
6. Exception for parapet and penthouse walls

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Roof insulation of R-7 – 10% of buildings.
- Roof Insulation of R-14 – 90% of buildings.
- Assumes buildings that have less than R-7 will be upgraded under the current code
- Percentages used account for buildings having between R-7 and R-14 and greater than R-14

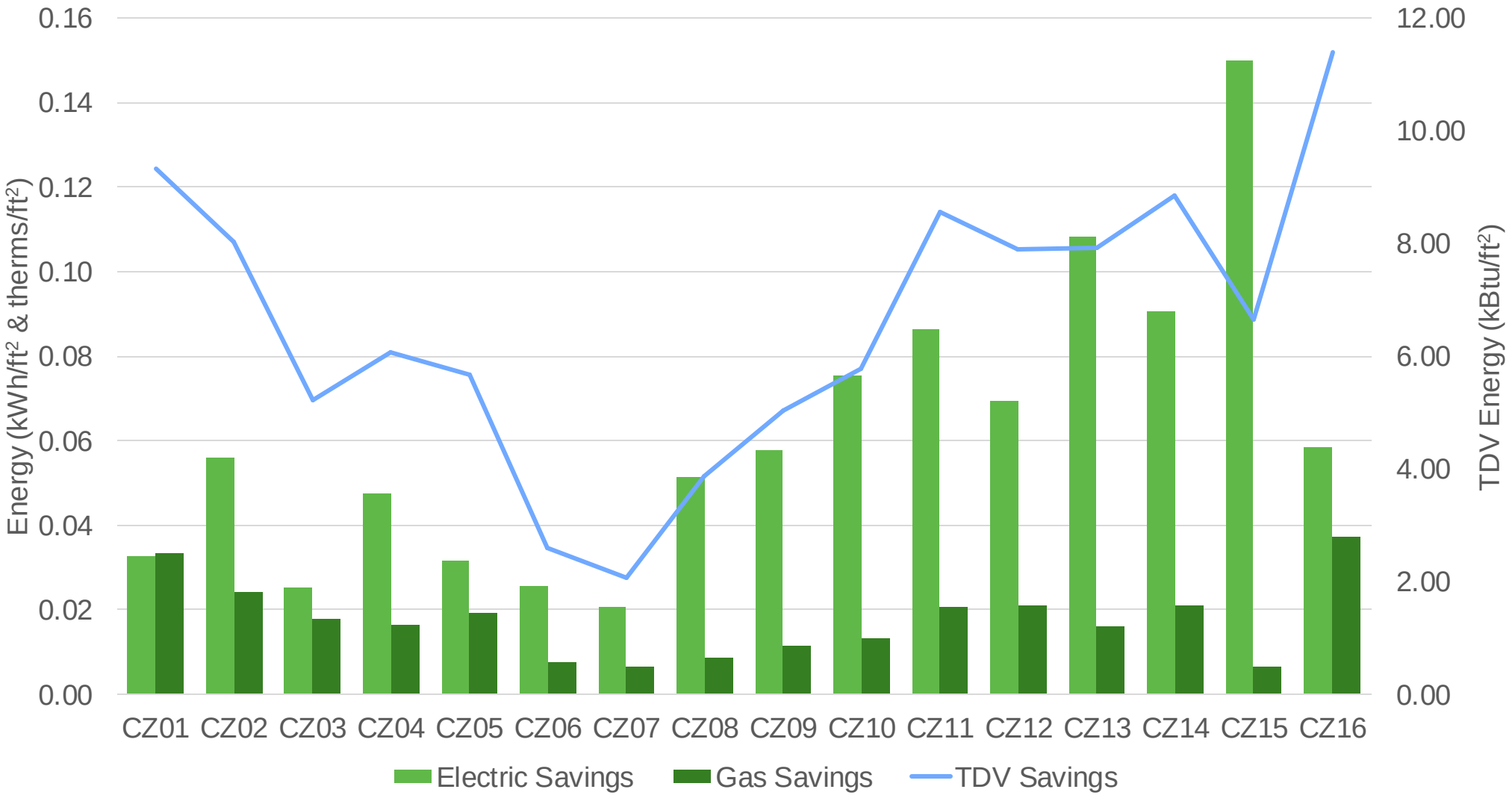
Proposed Conditions

- Roof insulation compliant with 2019 new construction.
- Roof recovers will have a lower baseline and lower proposed insulation

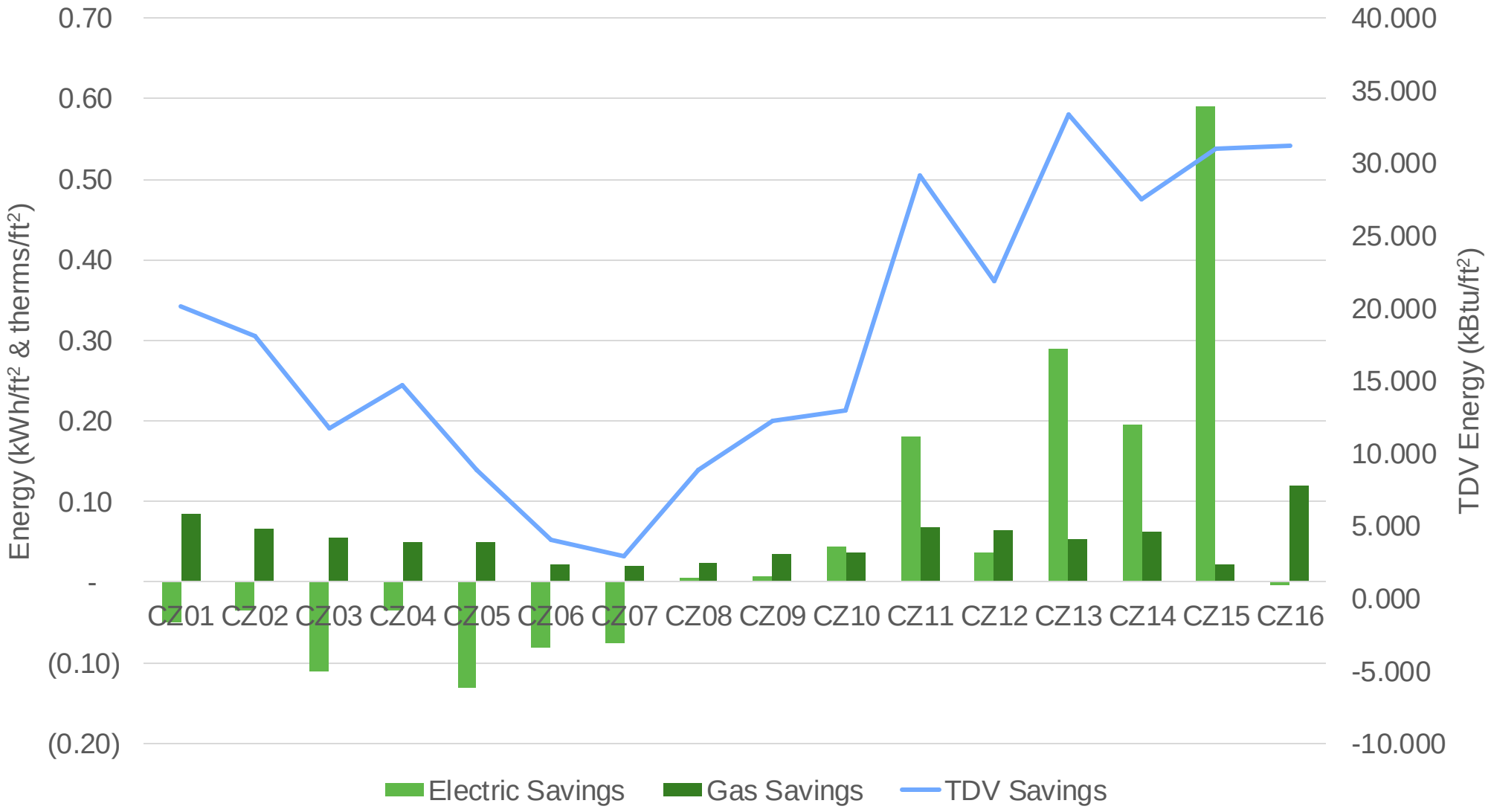
What is your reaction to this baseline?

- Both compliant with 2019 Energy Code
- Evaluated over 30-year period of analysis

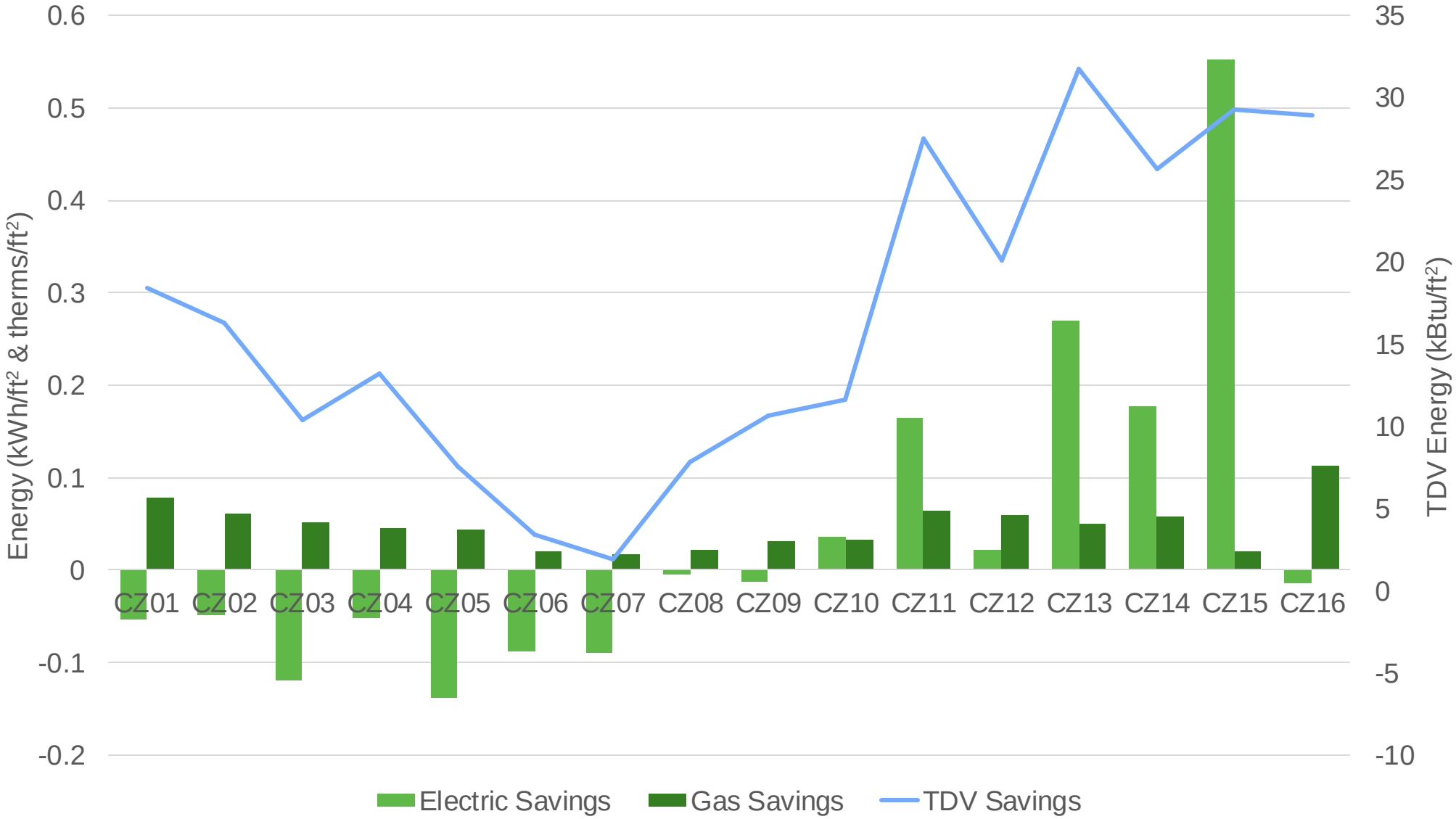
Energy Savings per ft² – Small Hotel



Energy Savings per ft² – Large Office



Energy Savings per ft² – Large Retail



Incremental Cost Information

- **To collect incremental costs a variety of sources were used:**
  - RS Means
  - Interviews with manufacturers and California contractors
  - Costs from the 2008 CASE Report[1], reviewed by California contractors
- **Included costs:**
  - Incremental costs for labor and material of extra insulation
  - Costs associated with the existing exemptions

3. Pacific Gas and Electric Company. 2008. Final Report Insulation Requirements. Codes And Standards Enhancement Initiative (CASE).

Incremental Per Unit Cost of Installing Insulation

Over 30 Year Period of Analysis

R Value	Rigid Insulation – with 25% markup ($/ft²)	Labor for Installation ($/ft²)	Total ($/ft²)	Total from 2008 CASE Report adjusted by historical cost indexes ($/ft²)
7 (Baseline)	0.60	0.90	1.50	1.12
11	0.80	1.11	1.91	1.22
14 (Baseline)	1.00	1.33	2.33	1.40
22	1.60	1.59	3.19	2.48
29	2.00	1.90	3.90	2.91

$ 1.50/ft²

Total Incremental Cost Used – blended for the different climate zone requirements, primarily going from R-14 to R-29

What are your reactions to these costs?

Incremental Per Unit Cost for Current Exceptions

Over 30 Year Period of Analysis

Penthouse and parapet walls

Removing the stucco from a 50 linear foot wall, adding a base flashing and counter flashing, and re-applying stucco:

- $59.94/linear foot using Davis Bacon Act (prevailing wages)

Mechanical equipment with low curbs (5 ton RTU/2000ft^2)

Curb adapter ($500), securing ductwork, extending gas supply line, extending supply cable, prepare the curb adapter, crane, and labor for lifting and replacing the unit and curb.

- Cost of $1500/2000ft^2

	Bay Area Roofing Contractor	Two Different Bay Area Mechanical Contractors
Cost	$2,000- $3,000	$1,500- $2,000

What are your reactions to these costs?

Changes To Tax Code in 2018

- $1 million of a reroof is tax deductible in the year of completion.
  - Previously having to amortize over 39 years
  - Can reduce the true cost of a reroof by 25-30%[4]
  - Makes financing roof replacements significantly easier

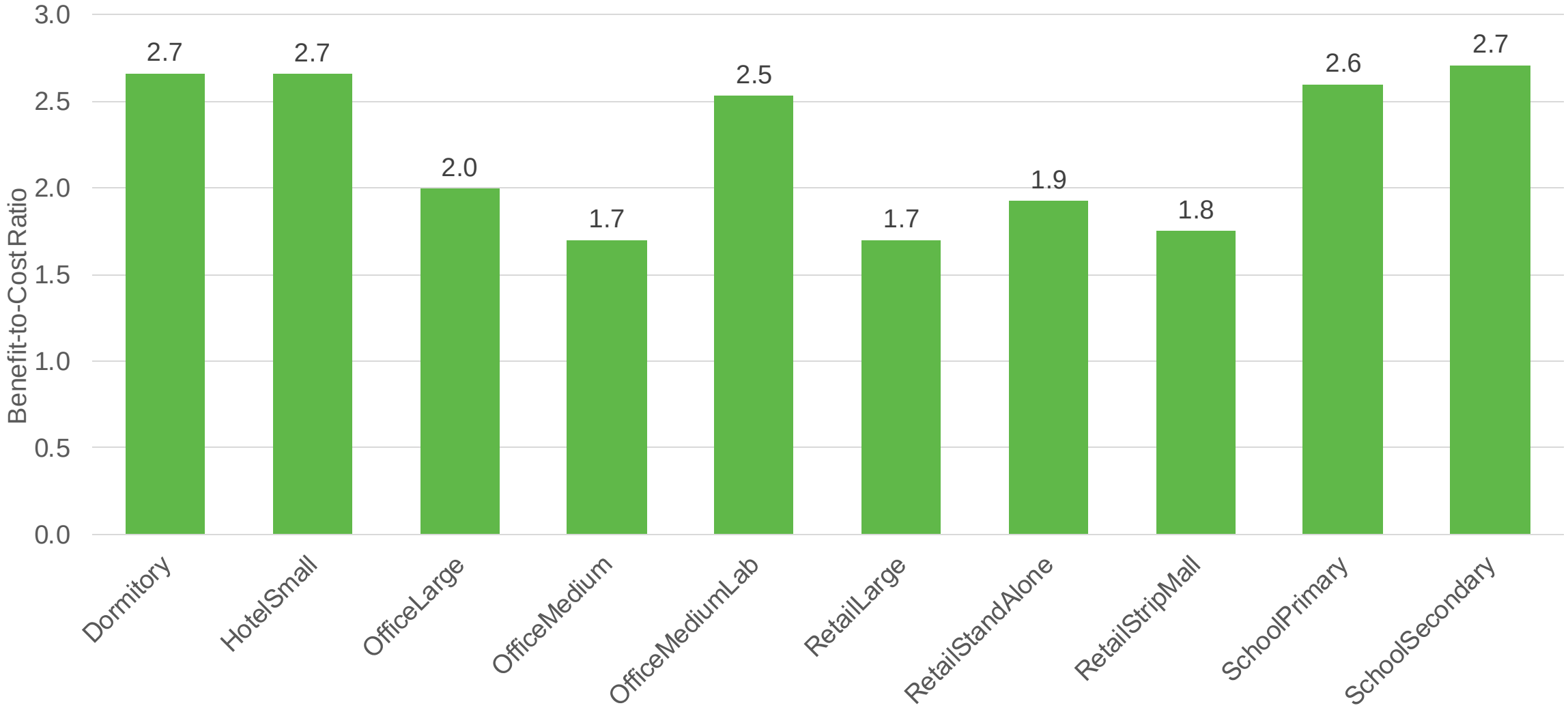
This was not included in our cost analysis -> our cost are overestimated as a result of the exclusion

4. PIMA. 2018. The Tax Cuts & Jobs Act: Commercial Building Roof Replacements. Polyiso.org.

Poll

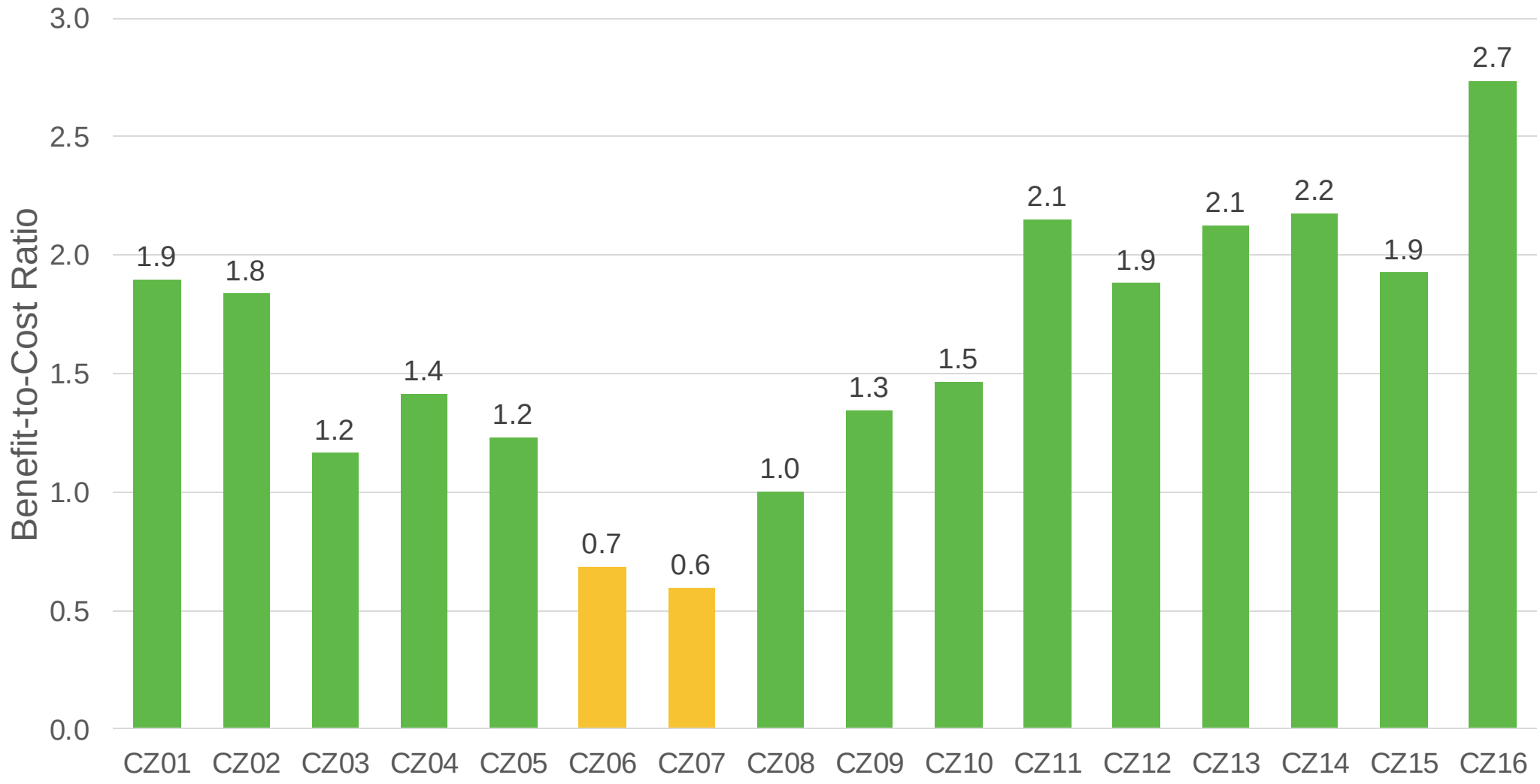
How should the changes to the tax code be incorporated into the Statewide CASE Team's analysis?

Energy Savings Results: Benefit-to-Cost Ratio by Building Type



Note: BC ratio does not include cost of exceptions or changes to tax code

Energy Savings Results: Benefit-to-Cost Ratio by Climate Zone

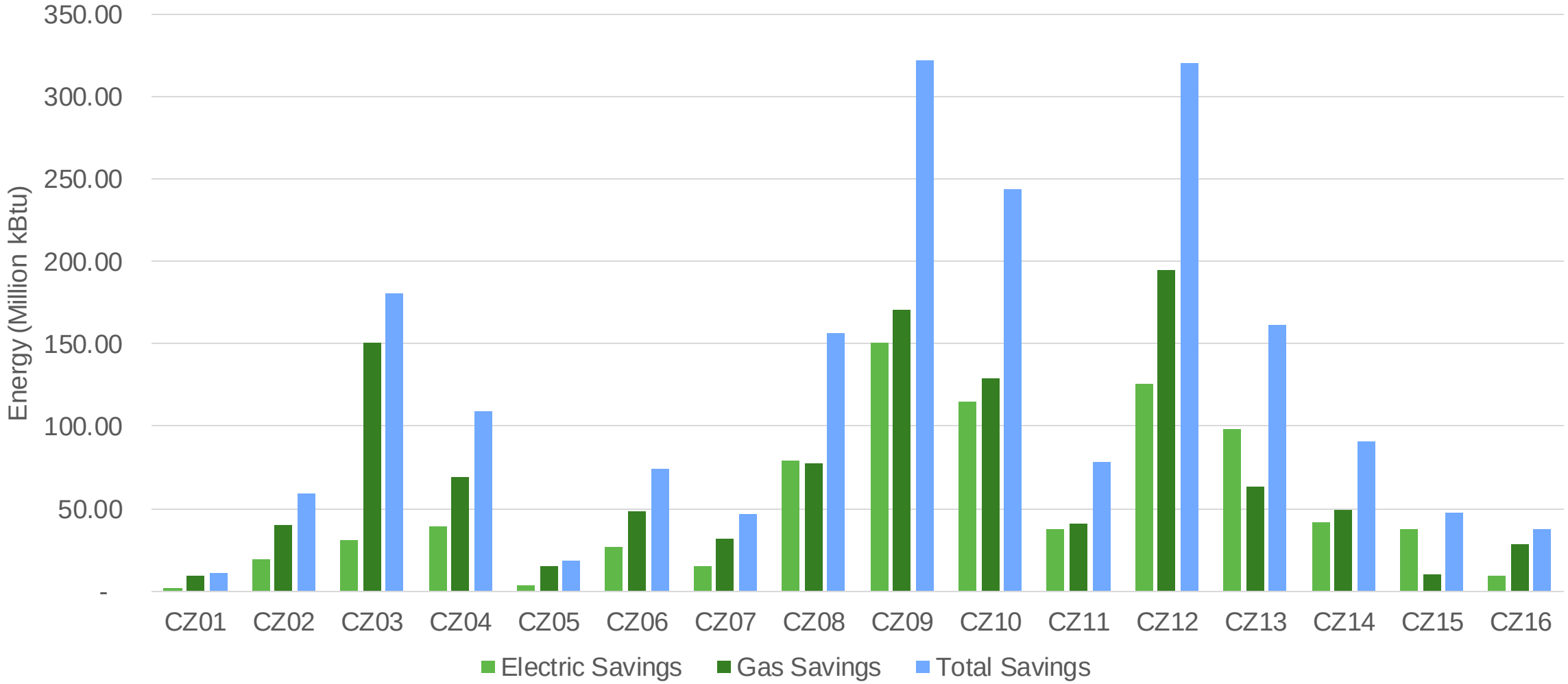


Note: BC ratio does not include cost of exceptions or changes to tax code

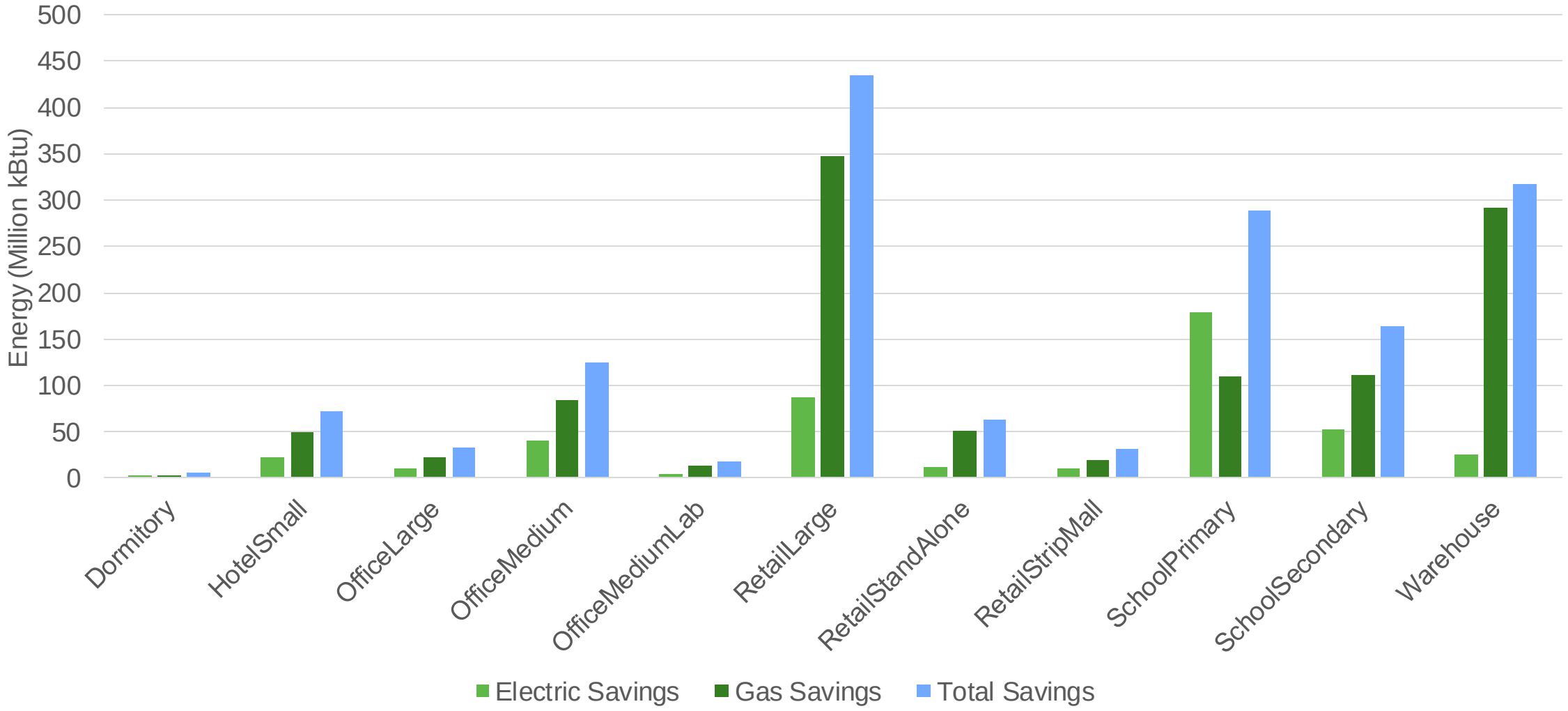
2023 Construction Forecast: Existing Buildings

Building Type	Total Statewide Existing Stock in 2023 (million square feet)	Percent of Million Square Feet Impacted by Proposal	Statewide (million square feet) Impacted by Proposal in 2023
Small Office	476.52	0%	--
Large Office	1,665.45	3%	49.96
Restaurant	238.92	0%	--
Retail	1,490.53	3%	44.72
Grocery Store	394.19	3%	11.83
Non-refrigerated Warehouse	1,402.32	3%	42.07
Refrigerated Warehouse	75.65	3%	2.27
Schools	724.95	3%	21.75
Colleges	379.99	3%	11.40
Hospitals	488.66	3%	14.66
Hotel / Motel	451.77	3%	13.55
Total	**7,788.95**	**2.7%**	**212.21**

First Year Statewide Savings – By Climate Zone



First Year Statewide Savings



First Year Statewide Energy Savings

Electricity Savings	Peak Electrical Demand Reduction	Natural Gas Savings	TDV Energy Savings
(GWh/yr)	(MW)	(million therms/yr)	(TDV million kBtu/yr)
23.8	25.2	4.3	1,957.8

Equivalent to annual energy consumption of 32,000 homes[5]

4. https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ca.pdf.

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Insulation requirements for **roof recovers**
- How to account for **below deck insulation**
- Ensuring there is enough above deck insulation to mitigate **moisture concerns**
- Handling **existing conditions** on the roof

Poll

What should be considered when dealing with below deck insulation in existing buildings?

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

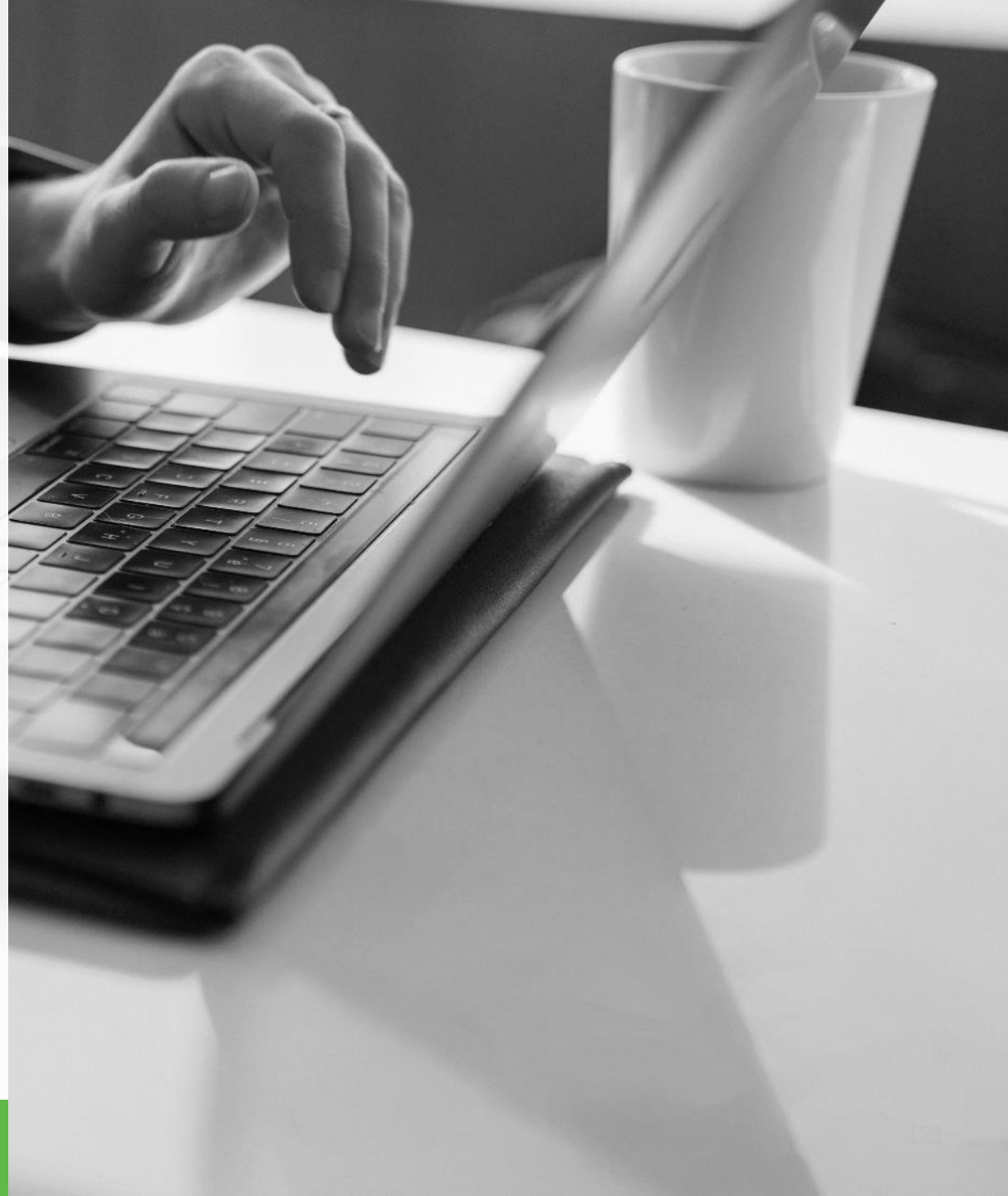
Compliance and Enforcement

- **Challenges with current compliance process:**
  - Building officials rarely ask contractors of roof alterations are meeting the insulation requirements
  - NRCC-ENV-E currently does not automatically prompt users to fill out the section for insulation
  - Projects are only inspected once, when the reroof is complete
- **Statewide CASE Team recommendations:**
  - Update NRCC-ENV-E
  - Provide education for building officials
  - Include roof replacements in the upcoming nonresidential registry
  - Require inspection of the insulation, including inspection below deck if applicable

What other compliance considerations are there?

Proposed Code Changes

- Draft Code Change Language



Draft Code Change Language

- **Updated** draft code language for this submeasure is available in the **resources tab.**
- **Section 141.0(b)2biii**
- The ~~exposed~~ area of the roof alteration shall be insulated to the levels specified in TABLE 140.3-B, C, or D ~~141.0-C~~. (New Construction Tables)
- Roof recovers shall be insulated to at least R-8
- In Climate Zones 3, 4, 5, 6, 7, 8, 9 ~~I~~if mechanical equipment is located on the roof and will not be disconnected and lifted as part of the roof replacement, insulation added may be limited to the maximum insulation thickness that will allow a height of 8 inches (203 mm) from the roof membrane surface to the top of the base flashing if the underside of the roof deck is not accessible for adding insulation.
- Eliminating the exception for base flashing height at penthouse or parapet walls

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Submeasure A: High Performance Windows

Submeasure B: Opaque Envelope

Submeasure C: Roof Alterations

Submeasure D: Cool Roofs

Cool Roofs Standard Proposal

- Updating prescriptive cool roof requirements for **new construction, additions, and alterations**
  - **Low-slope**: updating aged solar reflectance and aged Solar Reflectance Index (SRI) requirements
  - **Steep-slope**: updating aged solar reflectance, thermal emittance and aged SRI requirements

Current and proposed solar radiative properties for nonresidential roofs

Code	Slope	Aged Solar Reflectance*	Thermal Emittance*	Aged SRI
2019 (current)	Low	0.63	0.75	75
2022 (proposed)	Low	0.70	0.75	85
2019 (current)	Steep	0.20	0.75	16
2022 (proposed)	Steep	0.25	0.80	23

**Solar reflectance and thermal emittance are measured from 0 to 1.*

Insulation Tradeoff

- The **roof/ceiling insulation tradeoff** to low-slope roofs will remain.
- Values will be updated to achieve similar energy performance as cool roofs when also considering new insulation requirements.

TABLE 140.3 ROOF/CEILING INSULATION TRADEOFF FOR AGED SOLAR REFLECTANCE

Nonresidential			
Aged Solar Reflectance	**Metal Building Climate Zone 1-16 U-factor**	**Wood framed and Other Climate Zone 6 & 7 U-factor**	**Wood Framed and Other All Other Climate Zones U-factor**
0.62-0.56	0.038	0.045	0.032
0.55-0.46	0.035	0.042	0.030
0.45-0.36	0.033	0.039	0.029
0.35-0.25	0.031	0.037	0.028

Table 141.0-B Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance

Aged Solar Reflectance	Climate Zone 1, 3-9 U-factor	Climate Zone 2, 10-16 U-factor
0.62- 0.60	0.075	0.052
0.59-0.55	0.066	0.048
0.54-0.50	0.060	0.044
0.49-0.45	0.055	0.041
0.44-0.40	0.051	0.039
0.39-0.35	0.047	0.037
0.34-0.30	0.044	0.035
0.29-0.25	0.042	0.034

Tables from 2019 code language: https://ww2.energy.ca.gov/2018publications/CEC-400-2018-020/CEC-400-2018-020-CMF.pdf

Energy and Cost Impacts

- Per Unit Energy Impacts
- Cost Impacts
  - Incremental costs
  - Maintenance costs
  - Energy cost savings
- Cost-effectiveness
- Statewide Impacts

Methodology for Energy Impacts Analysis

- Energy modelling was conducted in **EnergyPlus** to gain a per square foot savings for the various Energy Commission building prototypes.
- The aged solar reflectance and thermal emittance levels of the roof were the only parameters modified.

Tools Used	CBECC-Com, EnergyPlus, Excel
Building Prototypes Modeled	All
Climate Zones Modeled	All

Assumptions for Energy Impacts Analysis

A **30-year period** of analysis was used

- The incremental cost of 2 roof covers was used.
- In year 1 and year 20

✓ Nonresidential buildings were modeled with the **solar radiative levels updated to the proposed levels**.

✓ The restaurant and small office building prototypes use **steep-slope** roofs while the remaining prototypes use **low-slope**.

✓ Roughly **5%** of all commercial building square footage per prototype building was **not included** due to the exception for roof area covered by solar PVs and other exceptions.

✓ **Alterations and New Construction** are modeled under the same parameters, with a baseline at the existing standard and proposed case reflective of this submeasure.

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 code

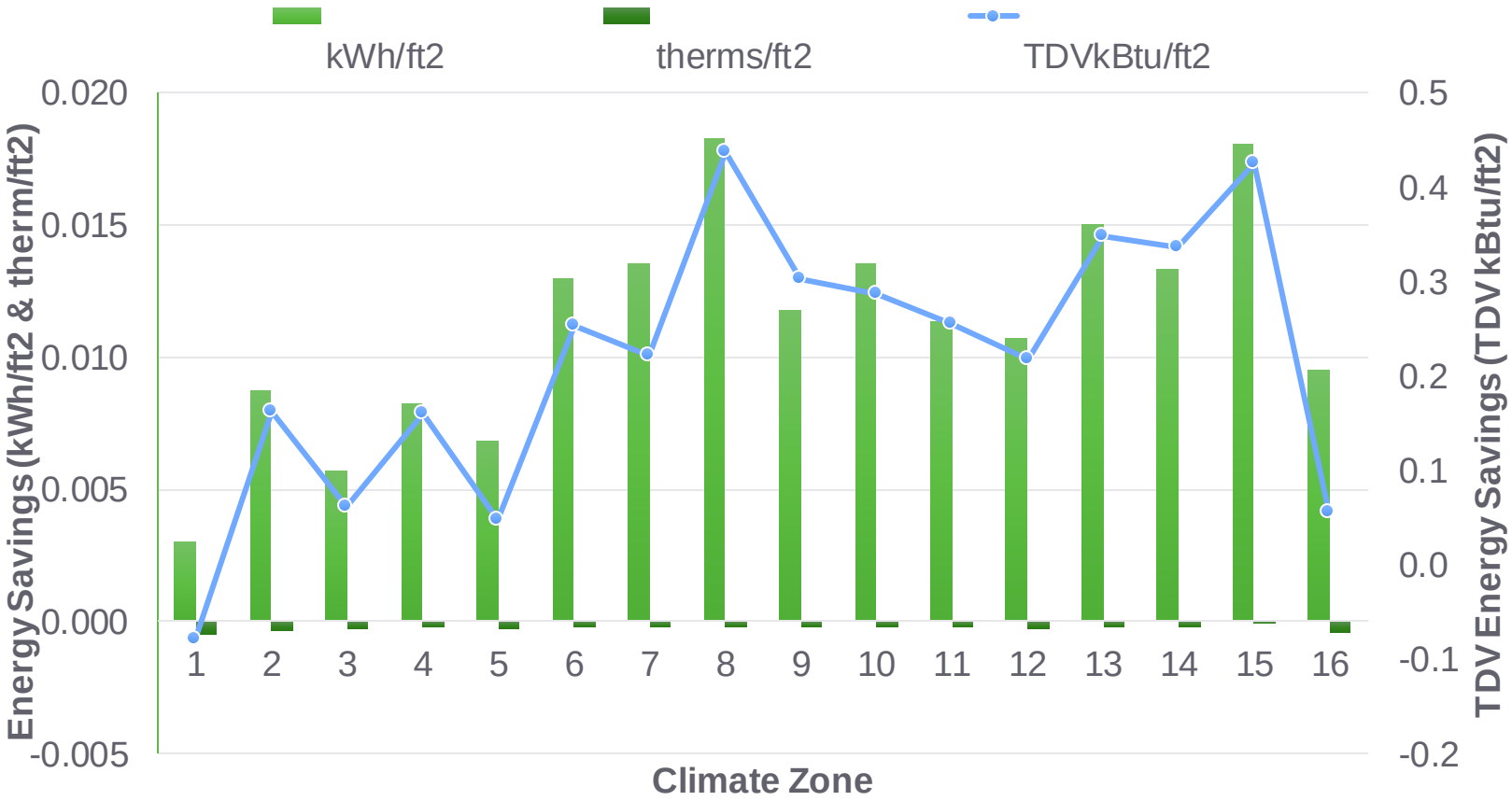
Aged Solar Reflectance	Thermal Emittance	Solar Reflective Index (SRI)
Low-slope		
0.63	0.75	75
Steep-slope		
0.20	0.75	16

Proposed Conditions

- Compliant with proposed levels

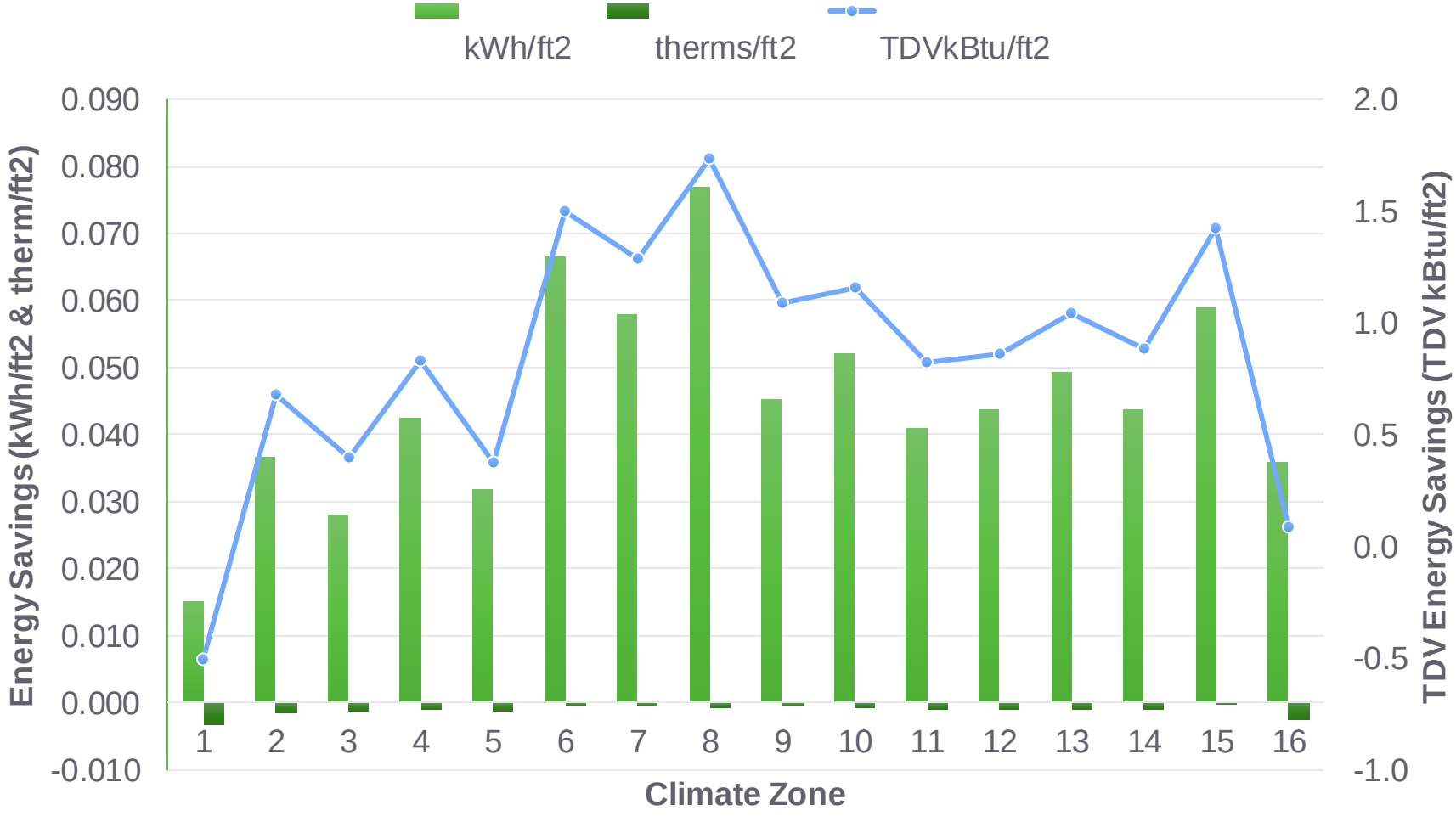
Aged Solar Reflectance	Thermal Emittance	Solar Reflective Index (SRI)
Low-slope		
0.70	0.75	85
Steep-slope		
0.25	0.80	23

Per Unit Energy Savings by Climate Zone – Medium Office

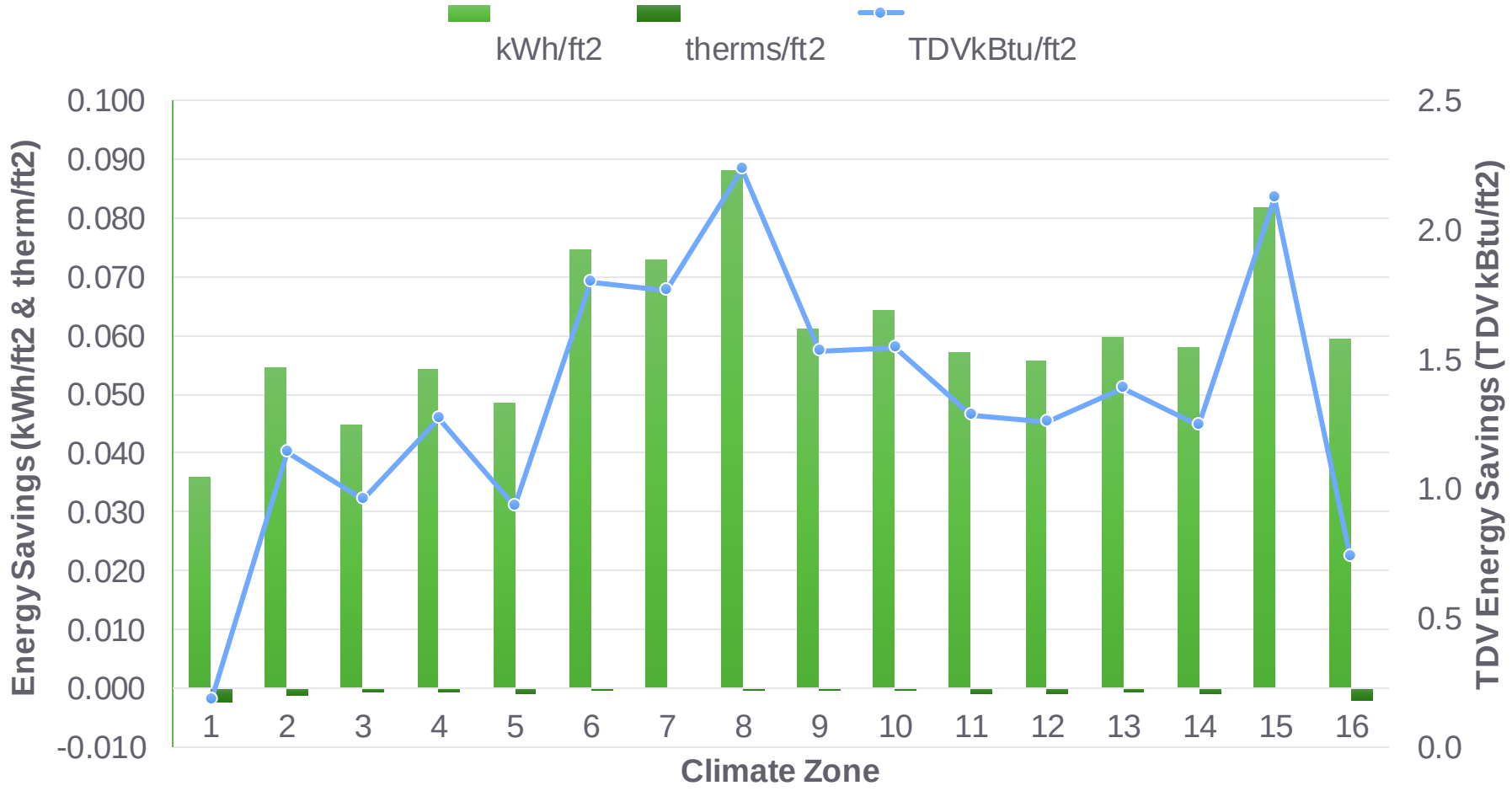


- Savings are greater in the warmer climate zones on average
- **Climate Zone 1** is the only climate zone that sees negative TDV savings.

Per Unit Energy Savings by Climate Zone – Primary School



Per Unit Energy Savings by Climate Zone – Small Office



Incremental Cost Information

- **To collect incremental costs a variety of sources were used:**
  - Online prices from retailers (primarily for coatings and asphalt shingles)
  - Calls to distributors around the state
  - Prior cool roof CASE Report[1]
- **Over 100 price points** were used for products with baseline and proposed reflectivity.
- Incremental costs from **product cost differences** were considered.
  - Labor and maintenance costs were **assumed to not change**.
- Contractor **mark-ups** were determined from RS Means

1. https://dpw.lacounty.gov/bsd/lib/fp/CoolRoofOrdinance/2016_FINAL_Cool%20Roofs%20Cost%20Effectivenss%20Report%20-%20All%20CZs.pdf

Cost Analysis Objectives

- While researching incremental costs for the cool roof submeasure, the Statewide CASE Team had **3 primary goals:**
  - Analyze costs at the baseline and proposed conditions for all types roofing products
  - Ensure cost estimates come from sources across the entire state
  - Costs come from a variety of manufacturers

Cost Sources

- The Statewide CASE Team contacted retailers and distributors across the state to find incremental costs and determine product availability.
- The following table is a summary of that outreach. Data points include information on products at baseline level reflectance and proposed level.

Roofing Type	Shingle	Single-Ply	Coating	Mod-Bit
Unique Cost estimates	60	22	22	7
Individual Products *(same products of different colors are considered the same)*	9	12	10	5
Retailer/Distributor Locations From Which Costs Were Collected*	7	16	11	4
Unique Retailers/Distributors From Which Costs Were Collected**	4	5	3	3
Separate Manufacturers	3	5	5	4

* Roofing cost estimates come from the Bay Area, Southern California as well as the Central Valley.
** Collected costs from the same distributor from different office locations

Incremental Cost

Cost Estimates by Product Type

Product Type (slope)	Coatings (low)	TPO (low)	PVC (low)	Cap Sheet (low)	Tile (steep)	Shingles (steep)	Metal (steep)
Contractor mark-up	*10%*	*20%*	*20%*	*33%*	*30%*	*40%*	*30%*
Cost per ft^2 at *baseline*	$0.47	$0.76	$0.95	$1.68	$1.18	$1.57	$4.55
Cost per ft^2 at *proposed*	$0.48	$0.78	$0.95	$1.94	$1.18	$1.64	$4.55
Incremental Cost per ft^2	**$0.01**	**$0.02**	**$0.00**	**$0.27**	**$0.00**	**$0.07**	**$0.00**

- Costs for coatings and shingles largely come from retailers
- Other costs come from distributors and include their mark-up
- Contractor mark-up assumptions presented in table

1. https://dpw.lacounty.gov/bsd/lib/fp/CoolRoofOrdinance/2016_FINAL_Cool%20Roofs%20Cost%20Effectivenss%20Report%20-%20All%20CZs.pdf

Incremental Costs

Low Slope Blended Cost

Roofing Product	TPO	PVC	Coating	Cap Sheet*	Blended
Low-slope Market Share[a]	40%	20%	30%	10%	
Incremental Cost per ft^2	$0.02	$0.00	$0.01	$0.27	**$0.04**

* Built-up roofs that use mod-bit cap sheets are listed under cap sheet. Remaining built-up roofs were added to the coatings category.

Steep Slope Blended Cost

Roofing Product	Shingle	Metal	Tile	Blended
Steep-Slope Market Share[b]	33%	33%	33%	
Incremental Cost per ft^2	$0.07	$0.00	$0.00	**$0.02**

a. Information is from the National Roofing Contractors Association 2015-2016 Survey
b. Information is from DOE CBECS data and Western Roofing Magazine roofing survey

Poll

Do the cost estimates presented above seem reasonable?

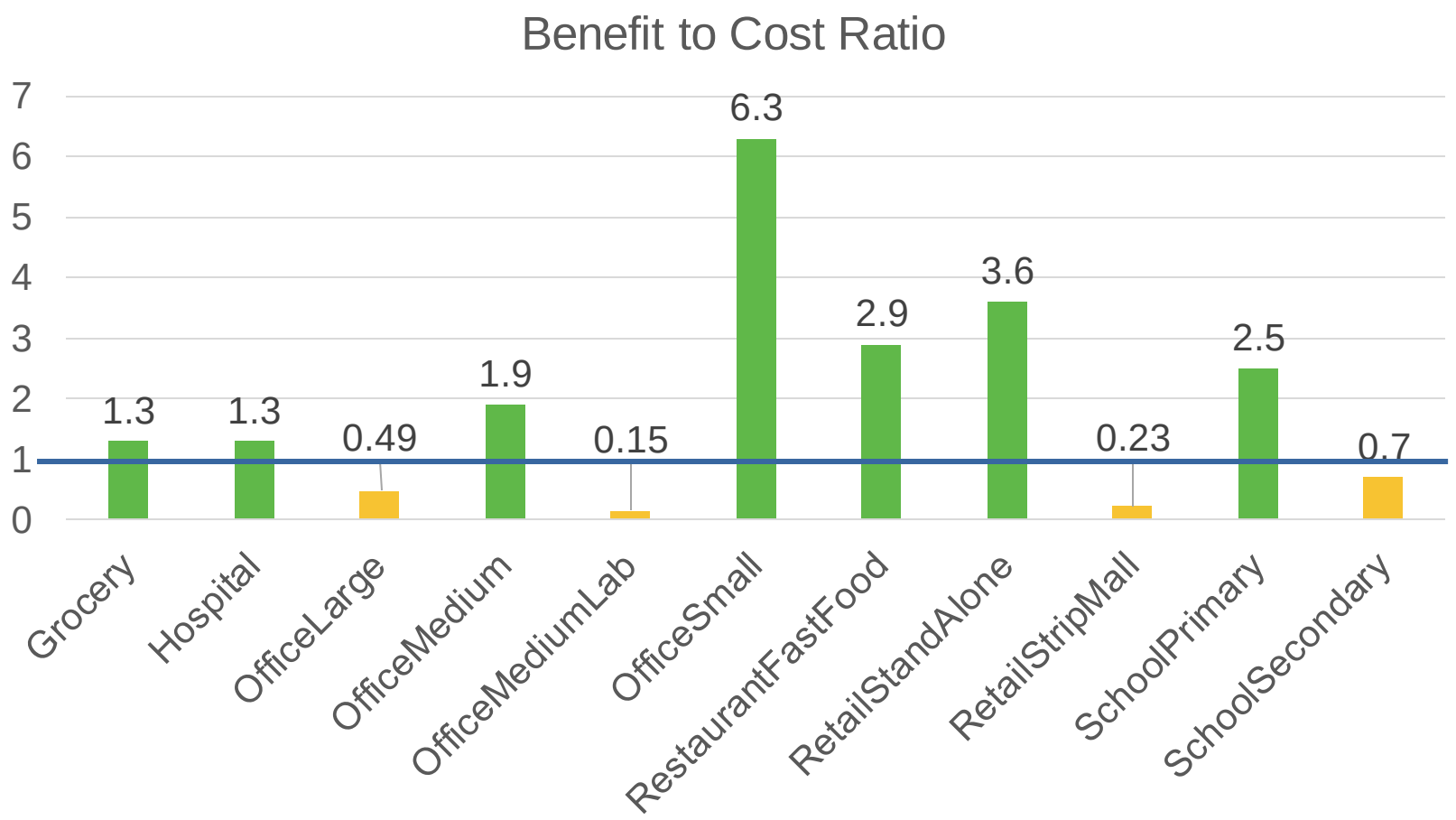
A. Yes

B. No

C. Not Sure

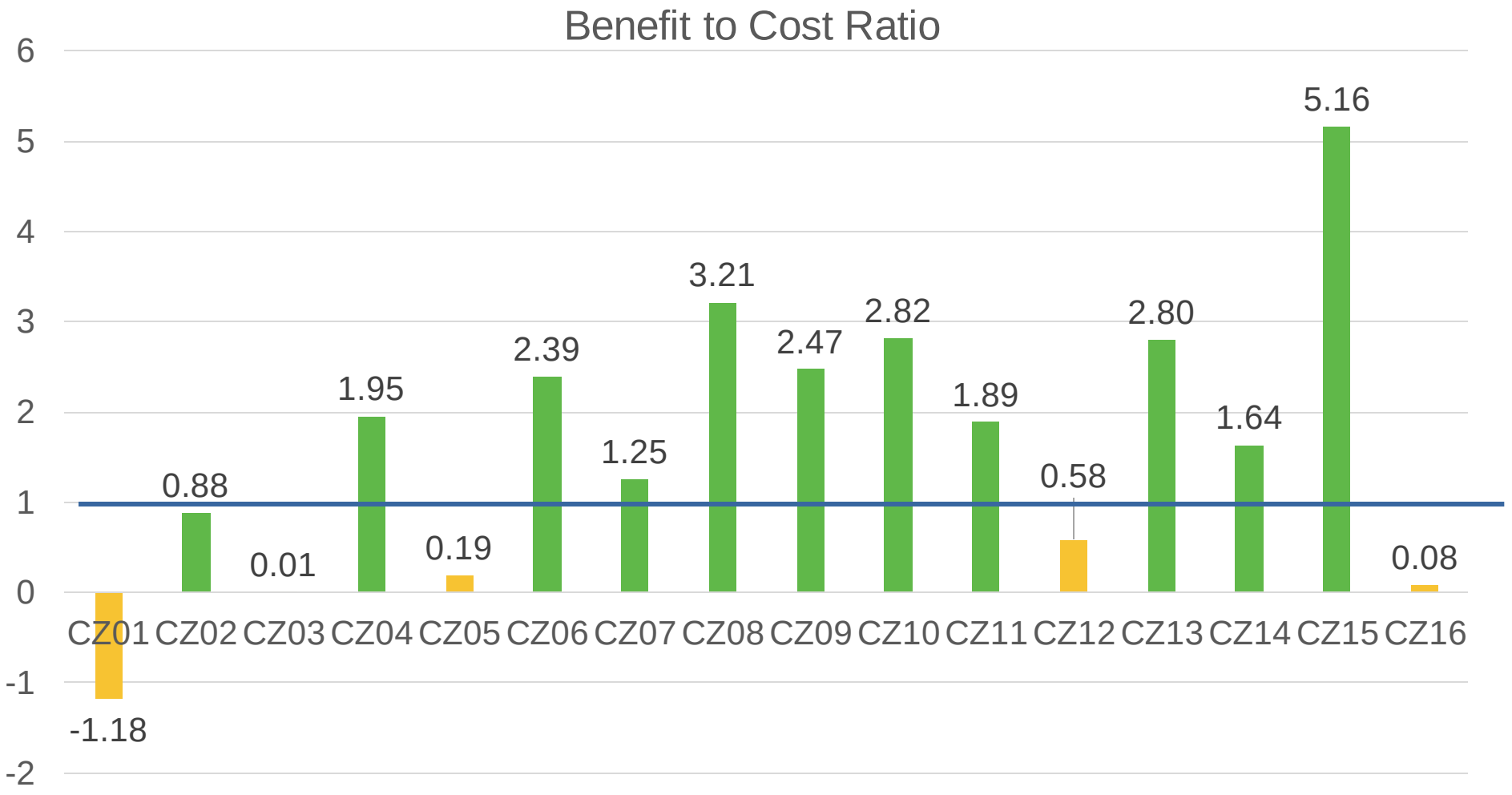
D. Other (please explain)

Benefit-to-Cost Ratio



- Overall benefit-to-cost ratio of roughly **2.0**

Benefit-to-Cost Ratio



2023 Construction Forecast: New Construction

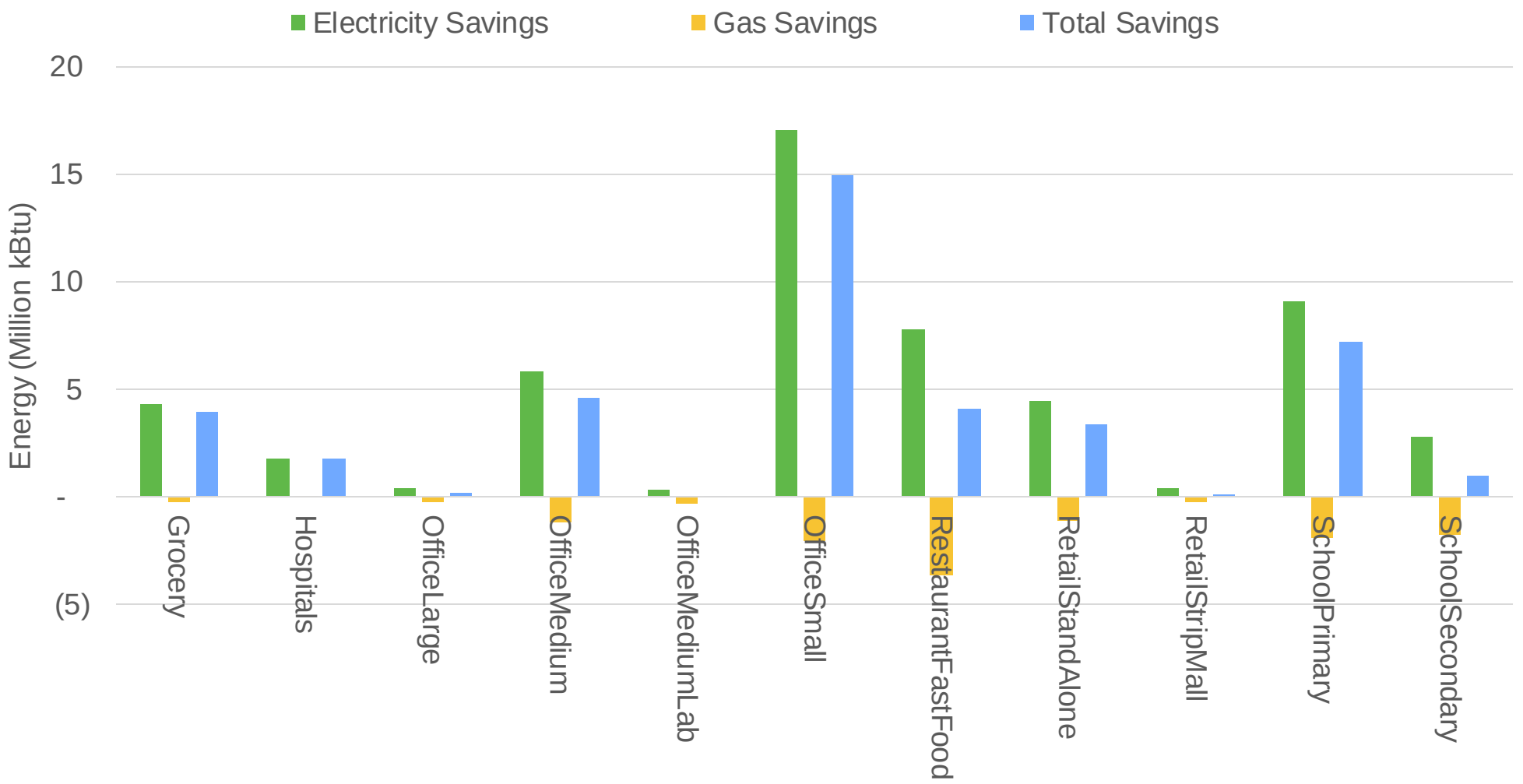
Building Type	Total Statewide New Construction Permitted in 2023 (million ft^2)	Percent of Statewide New Construction Impacted by Proposal	Statewide New Construction Impacted by Proposal in 2023 (million ft^2)
Nonresidential	161	55%	86

- **Warehouses:** not included in savings since only heating loads are included in building prototypes
- **Hotels and motels:** no change proposed (lack of savings from occupancy loads)
- **Retail mixed use:** not included in simulations (no roof in building prototype software)
- **Large Retail and Assembly**: will be included in Final analysis (not included due to errors in modeling)
- **Climate Zone 1 and 16:** exempted from this proposal

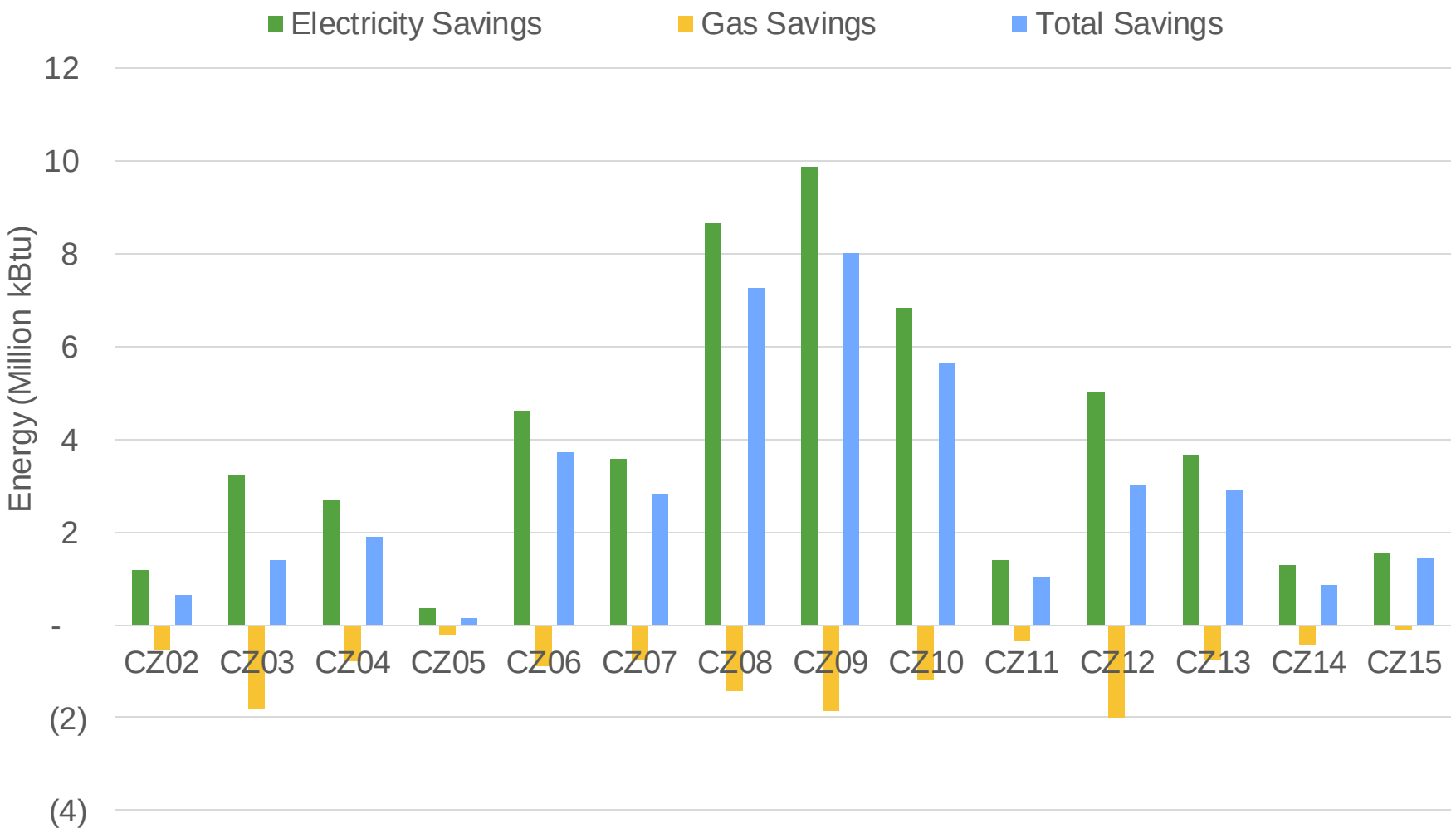
2023 Construction Forecast: Existing Buildings

Building Type	Total Statewide Existing Stock in 2023 (million ft^2)	Percent of Floorspace Impacted by Proposal	Statewide Floorspace Impacted by Proposal in 2023 (million ft^2)
Small Office	476.52	5%	23.83
Large Office	1,665.45	5%	83.27
Restaurant	238.92	5%	11.9
Retail	1,490.53	5%	74.53
Grocery Store	394.19	5%	19.7
Non-refrigerated Warehouse	1,402.32	0%	0.00
Refrigerated Warehouse	75.65	0%	0.00
Schools	724.95	5%	36.25
Colleges	379.99	5%	19.00
Hospitals	488.66	5%	24.43
Hotel / Motel	451.77	0%	0
Total	**7,788.95**	**4%**	**292.9**

Statewide Savings – New Construction by Building Type

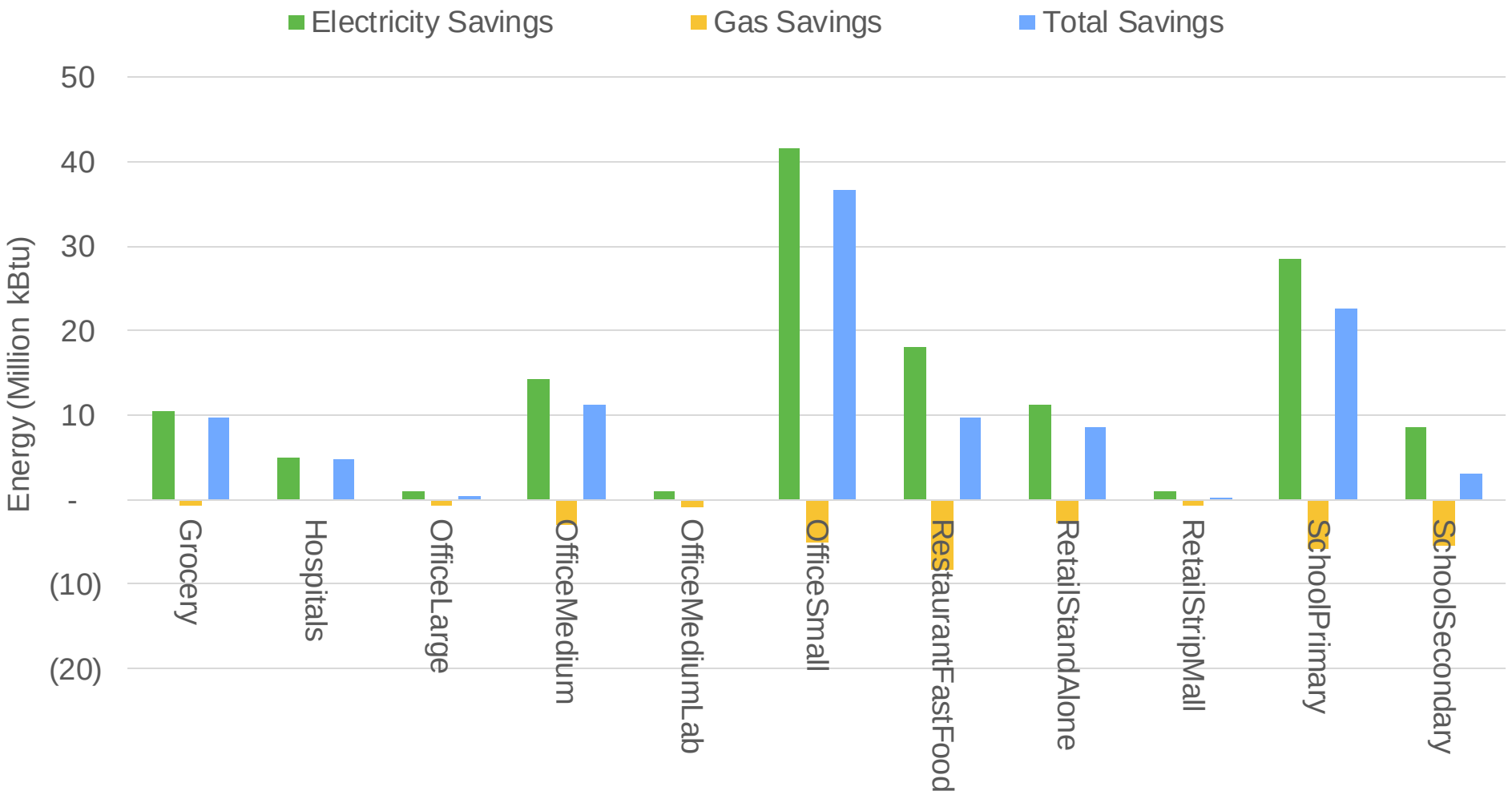


Statewide Savings – New Construction by Climate Zone



In total, roughly **41 million TDV kBtu/yr** will be saved from New Construction

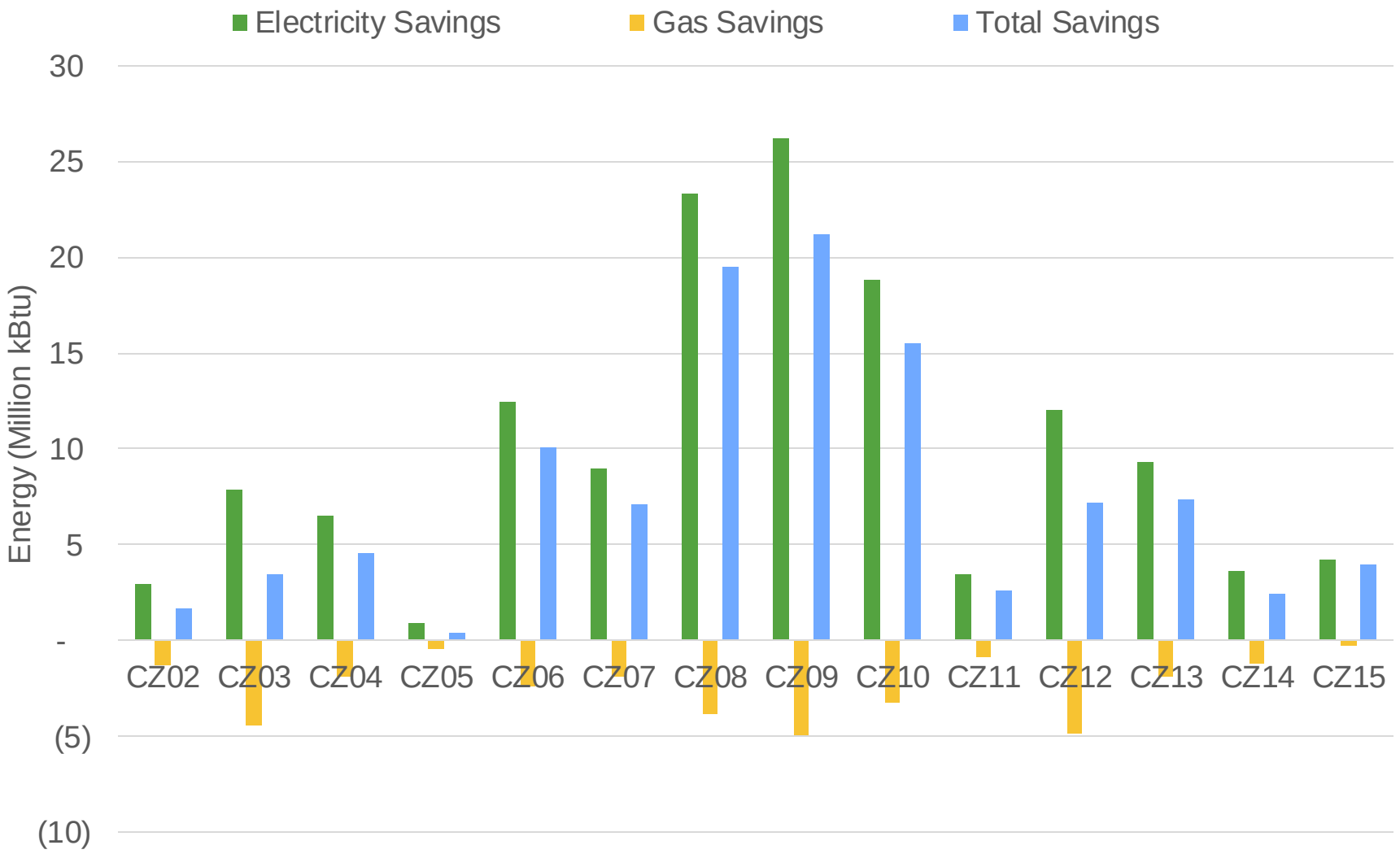
Statewide Savings – Alterations by Building Type



107 million TDV kBtu/yr

will be saved in alterations

Statewide Savings – Alterations by Climate Zone



In total, this proposal will save **148 million TDV kBtu** per year

Technical and Market Considerations

- Product Availability
- Moisture

Technical Considerations: Survey Responses

- The cool roof survey was sent to hundreds of members of the roofing industry. Respondents include roof contractors, energy consultants, architects, manufacturers and others. There were 36 respondents in total.

What are important technical considerations of the Statewide CASE Team to consider?

Issue	Number of respondents to note as concern
Cleaning	19
Glare	13
Moisture Accumulation	11
Added Inspection	7
Roof Decay	6

- More information on *moisture accumulation* is discussed later on

Market Overview

- Roofing products used to meet Title 24, Part 6 prescriptive cool roof requirements must be rated and labelled by the **Cool Roof Rating Council (CRRC),** which maintains a product database.
  - Thus, all relevant products for prescriptive cool roof requirements in California are in the CRRC database.
- All types of roofing products that meet the current standards have multiple products that meet the proposed levels.

Slope Type	Number Exceeding Current Title 24, Part 6 Requirements	Number Meeting or Exceeding Proposed Levels	Percentage (%)
Steep	1,695	1,471	87
Low	679	492	72

Produce Availability – Market Overview

- **Information in following slides is a summary of information from the Cool Roof Rating Council (CRRC) directory**

- **Notes about CRRC directory**
  - Data from directory demonstrates technical feasibly from range of product classes and manufacturers
  - Listed products may not be available for purchase or sale (see discussion of product availability on previous slide)
  - CRRC lists product types, not unique models; some products with one listing represent more than one unique model.
  - Directory includes:
    - All roofing products that can be used to comply with prescriptive requirements
    - Roofing products that do not meet prescriptive requirements; rated values can be used in performance calculations
  - Products that are not rated by CRRC can be used in California if using the performance approach – default values used in performance modeling

Cool Roof Market Overview – Steep Slope

Product Type	Number of Products in CRRC Directory	Number of Products Meeting Prescriptive Cool Roof Requirements (2019 Code)	Number of Products Meeting Prescriptive Cool Roof Requirements (Proposed 2022Code)	% that meet 2019 standards that also meet 2022 proposal
Asphalt Shingle	193	156	62	40%
Asphaltic Membrane	53	49	49	100%
Built-Up Roof	1	1	1	100%
Modified Bitumen	52	48	48	100%
Coating	507	504	504	100%
Fluid-Applied Membrane	20	20	20	100%
Metal	496	495	481	97%
Polymer/Composite	39	39	38	
Single-Ply	152	145	144	99%
Stone/Rock	2	2	2	100%
Tile	329	282	168	57%
Wood	3	3	3	100%
Total	**1794**	**1695**	**1471**	**87%**

Cool Roof Market Overview – Low Slope

Product Type	Number of Products in CRRC Directory	Number of Products Meeting Prescriptive Cool Roof Requirements (2019 Code)	Number of Products Meeting Prescriptive Cool Roof Requirements (Proposed 2022Code)	% that meet 2019 standards that also meet 2022 proposal
Asphalt Shingle	4	0	0	n/a
Asphaltic Membrane	116	27	8	30%
Built-Up Roof	1	1	0	0%
Modified Bitumen	115	26	8	31%
Coating	646	488	386	79%
Fluid-Applied Membrane	25	19	16	84%
Foam	1	1	0	0%
Metal	392	25	14	56%
Polymer/Composite	3	0	0	n/a
Single-Ply	196	118	68	58%
Stone/Rock	6	1	0	0%
Tile	2	0	0	n/a
Total	**1,391**	**679**	**492**	**72%**

- Since this is a prescriptive proposal, the performance path can be used with products not listed in the CRRC database
- Additionally, the roof insulation tradeoff table can be used to comply with the prescriptive requirements for products that are not at the proposed level

Moisture Dissipation

- A **common maintenance concern** broached by various parties was the increased rates of moisture build up associated with cool roof installation.
  - The Statewide CASE Team is determining the added moisture accumulation impact of moving from an aged solar reflectance level of 0.63 to 0.70.
  - Since cool roofs reduce the overall temperature of the roof, the membrane might be more likely to stay below the dew point temperature which could allow condensation to grow.
  - In dark roofs, the membrane would get hot enough during summer months to dry out any condensation. This may not necessarily be the case with cool roofs.

Moisture Dissipation (continued)

- The Statewide CASE Team is reviewing analyses of moisture accumulation issues for both wood deck and steel framed roofs.[1,2,3,4,5]
  - Assumption: 75% of roofs having wood decks. 25% having steel
- Field studies conducted by industry groups have also analyzed this issue for steel-frame roofs in national Climate Zones 4 and 5.[6,7]
- Additionally, the Statewide CASE Team is reviewing surveys of roofing contractors to understand their experience with this issue

1.https://www.sciencedirect.com/science/article/abs/pii/S0360132312002995 (Ahrab, & Akbari)
2. http://rci-online.org/wp-content/uploads/2013-CTS-kehrer-pallin.pdf (Kehrer & Pallin)
3. https://www.astm.org/DIGITAL_LIBRARY/STP/PAGES/STP159920160104.htm (Desjarlais, Pierce, Pallin)
4. https://info.ornl.gov/sites/publications/Files/Pub47188.pdf (Pallin, Kehrer, Desjarlais)
5. https://www.sciencedirect.com/science/article/abs/pii/S0360132311003714 (Saber et al)
6.. https://pdfs.semanticscholar.org/9d38/c351e9fe9c40b9d5671279b24b9dec98fe2e.pdf (Kehrer & Ennis)
7. https://www.roofingcontractor.com/articles/90602-study-targets-cool-roofs (DiPietro)

Moisture Dissipation Mitigation

- According to reports and stakeholders, installing above deck installation can help mitigate moisture dissipation issues.[1,2]
- Statewide CASE Team is considering above added insulation requirements under the roof alterations submeasure.
- We will evaluate the combined cost and energy savings of roof insulation and cooler roofs.

Are there any keep considerations we should bear in mind on this analysis?

1. https://iibec.org/cool-roofs-west-coast-roofing-science-task/
2. https://iibec.org/wp-content/uploads/2013-03-dregger.pdf

Summary of Proposed Revisions

Roof Alterations + Cool Roofs

Current Code Requirements

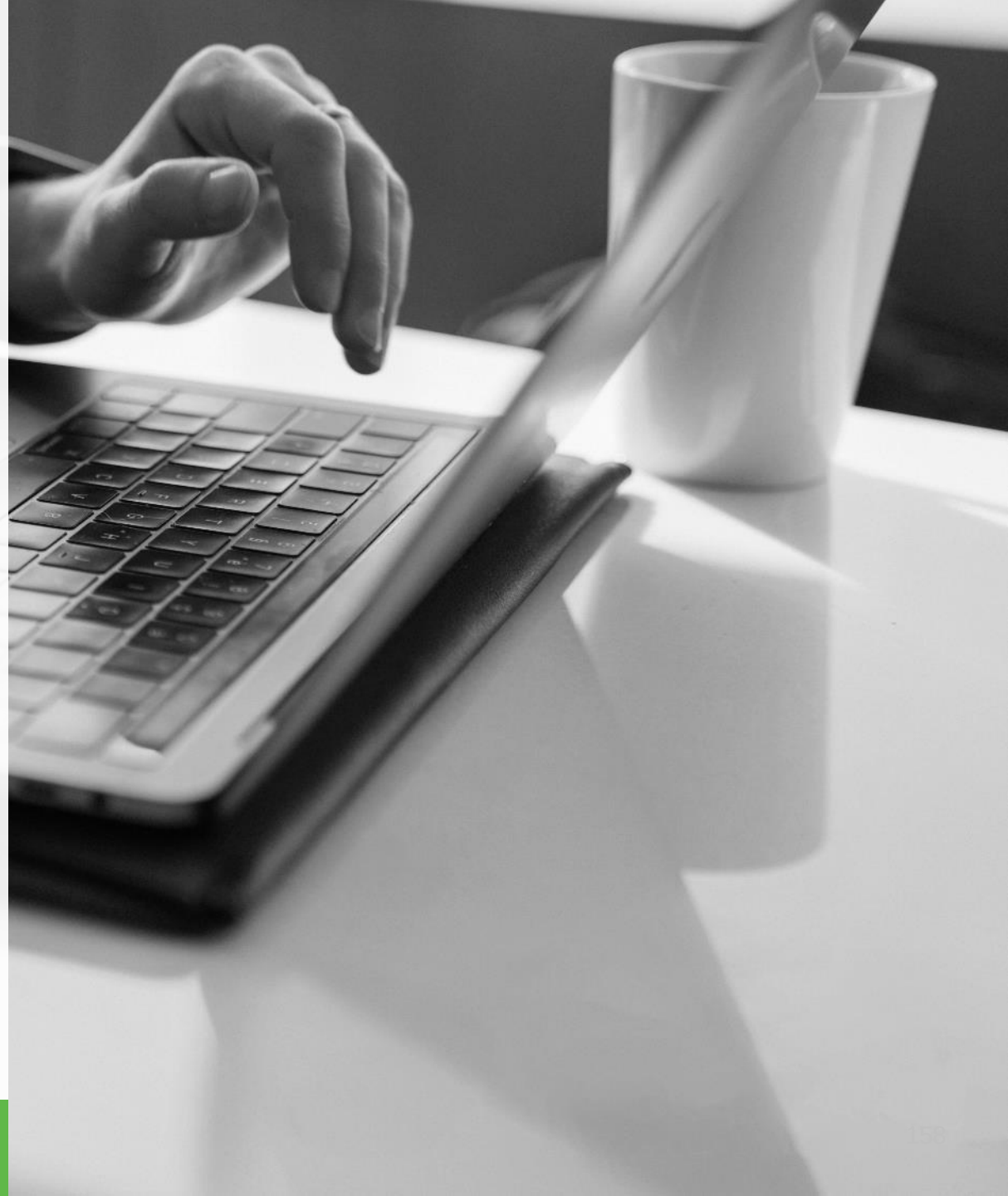
- Above Deck Roof Insulation
  - Baselines for roof replacement and roof recover
- Cool Roof
  - Aged solar reflectance of 0.63
  - Thermal emittance of 0.75

Proposed Code Requirements

- Above Deck Roof Insulation
  - New construction insulation for roof replacements
  - Adding R-8 for roof recovers
- Cool Roofs
  - Aged solar reflectance of 0.70
  - Therma emittance of 0.75

Proposed Code Changes

- Draft Code Change Language



Draft Code Change Language

- **Updated** draft code language for this submeasure is available in the **resources tab.**
- Solar radiative levels were updated to the proposed levels.
- The updated insulation tradeoff tables will be finalized prior to publication of the Final CASE Report.

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

We want to hear from you!

+ Stakeholder meeting feedback informs utility-sponsored CASE Reports.
+ Draft CASE Reports for today's topics will be published in **June 2020**.

*Comments will be considered as they are received. Stakeholders are invited to submit feedback on today's presentation, and the Draft CASE Report to help shape the **Final** CASE Report submitted to the Energy Commission.*

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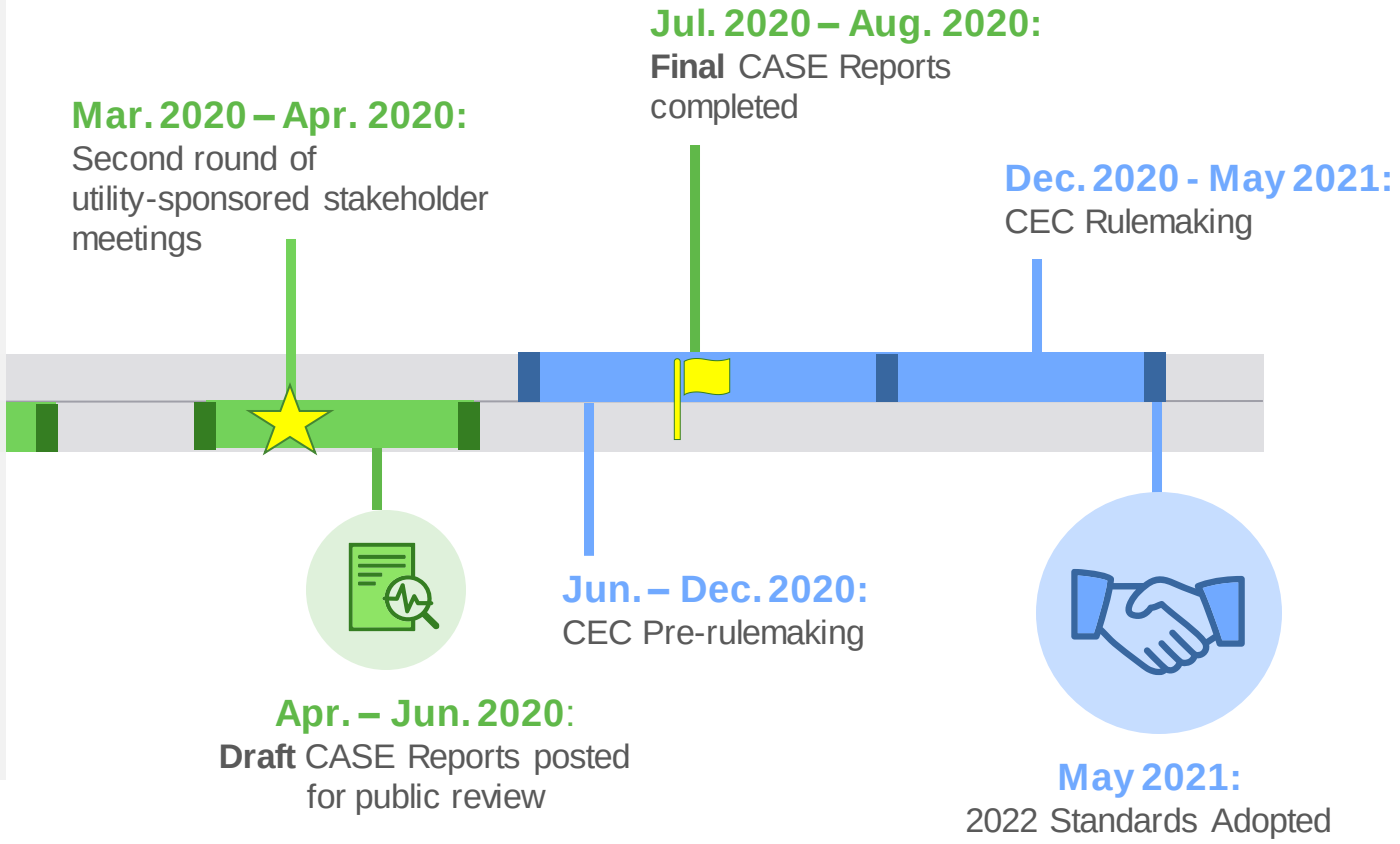

Upcoming Meetings

Meeting Topic	Building Type	Date
Lighting	NR/MF	Tuesday, March 3, 2020
Single Family Whole Building	SF	Thursday, March 5, 2020
Nonresidential and Single Family HVAC Part 1: Data Centers, Boilers, Air Distribution, Variable Capacity	NR/SF	Thursday, March 12, 2020
Water Heating and Multifamily All Electric Package	MF	Tuesday, March 17, 2020
Single Family Grid Integration	SF	Thursday, March 19, 2020
Multifamily HVAC and Envelope	MF	Wednesday, March 25 2020
Covered Processes Part 1: Refrigeration System Opportunities	NR	Thursday, April 2, 2020
Nonresidential HVAC and Envelope Part 2: Reduced Infiltration, HVAC Controls (Air Efficiency, DOAS)	NR	Tuesday, April 14, 2020
Covered Processes Part 2: Controlled Environment Horticulture	NR	Thursday, April 16, 2020
Nonresidential Envelope: High Performance Envelope	NR	Thursday, April 23, 2020
Multifamily Restructuring	MF	Thursday, May 7, 2020

Thank you for your participation today

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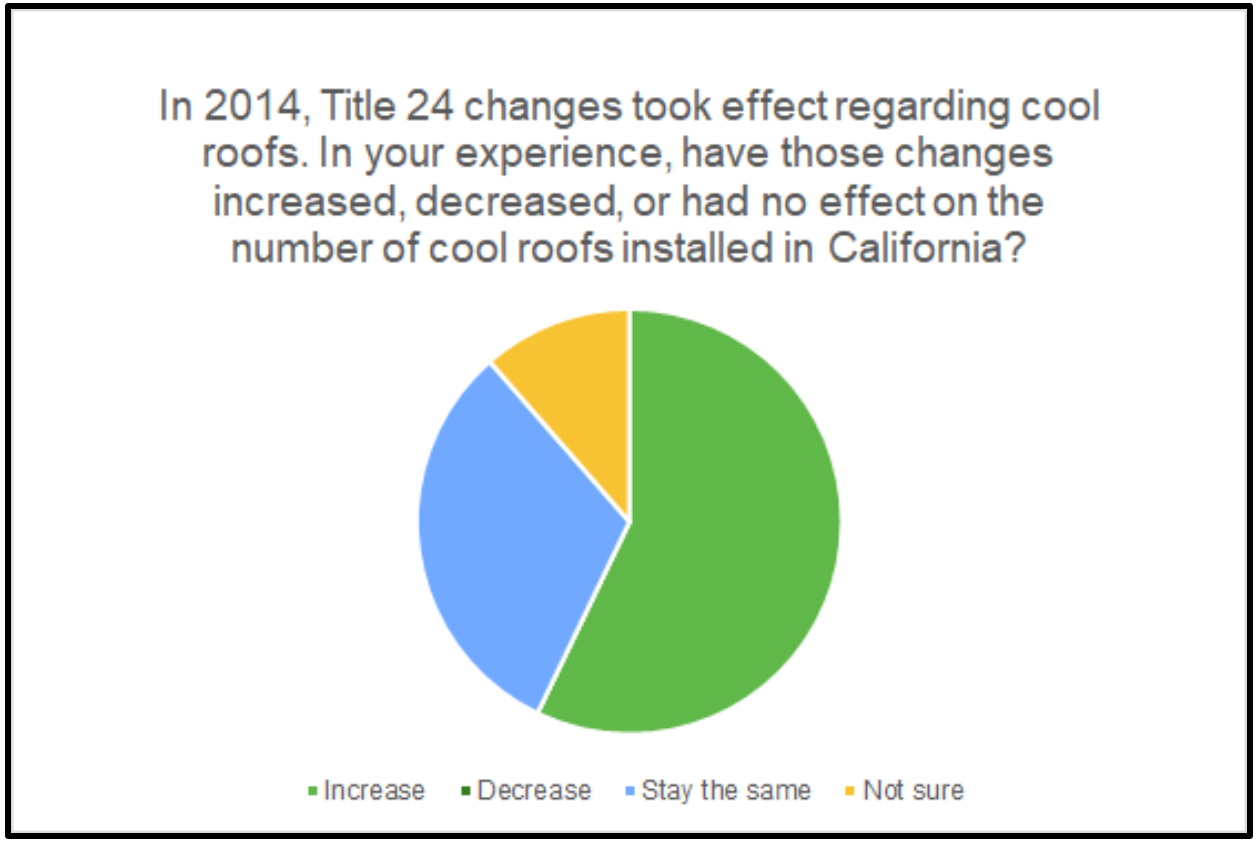
Please complete the closing polls below

Appendix

Cool Roof Survey Results

- **35 responses** to a Statewide CASE Team survey for roofing contractors, consultants, building designers, and others.

Type of Roofing	% of respondents who work with roofing type
Single-Ply	77
Built-Up Roofing	31
Coatings	31
Asphaltic Membrane	23
Asphalt Shingle	23
Metal	5



1. Note: No respondents said the number of cool roofs has decreased since 2014 legislation